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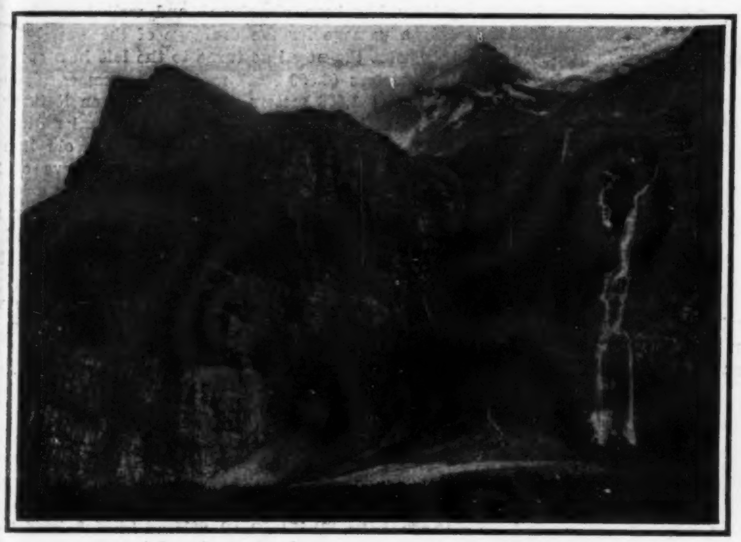
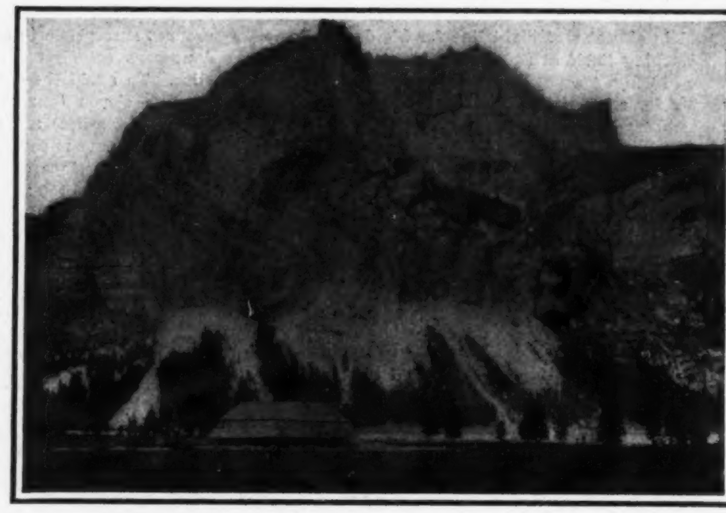


THE MOUNTAIN BARRIER WHICH WILL BE PIERCED BY THE LOETSCHBERG TUNNEL FOR A DISTANCE OF 9.03 MILES.



THE ENORMOUS BARRIER OF CONTORTED ROCK WHICH THE LOETSCHBERG TUNNEL WILL PIERCE.

By courtesy of the Sphere.

BORING THROUGH THE BERNESE OBERLAND. THE NEW ROUTE WILL GO STRAIGHT ACROSS SWITZERLAND TO ITALY.

The panoramic view of the Loetschberg tunnel is taken looking southward toward Italy. In foreground is the Kandersteg plateau with northern end of tunnel which stretches away toward the southern entrance to the Rhone Valley. A gallery is shown in circular view to the left. A head of ventilation shaft is shown in left hand upper corner and other views of works on the right.

BORING THROUGH THE BERNESE OBERLAND.

BORING THROUGH THE BERNESE OBERLAND.*

A GIGANTIC ENGINEERING TASK.

The gigantic work of tunneling the Bernese Oberland is rapidly approaching the completion of its first stage—that of the actual first rough boring of the tunnel. When completed the zigzag route which one now has to take to reach Italy will be straightened out in a marvelous manner. Hitherto on reaching Basle or Berne the traveler found himself unable to further pursue a direct course for Rome, Venice, or Brindisi—the great barrier of the Bernese Oberland stood in the way. The traveler found that he had to turn out of his direct route toward Lausanne and thence pursue his way along the Rhone valley to the Simplon tunnel. The new scheme will enable the traveler to forge ahead in almost a straight line for his destination.

Détaching itself at Spiez on the south bank of the Lake of Thun from the Berne-Interlaken line, and following for some time the railway from Frutigen, the Loetschberg line climbs the valley of the Kandar, open to the sky as far as Buhlstutz, whence by a double curve partly underground it climbs up to the plateau of Kandersteg, at the extreme end of which it enters the great tunnel, then passes under the valley of Gasteren and the neck of Loetschen to emerge above Goppenstein, a village in the valley of the Lonza, which opens into the valley of the Rhone above Gampel. From there, keeping close to the left side of the valley by a series of galleries, it comes out above Hohtenn, at a great height above the bed of the Rhone, following afterward the right side of the valley of the Rhone and leaping numerous gorges in order to join the Simplon line at Brigue station. The total distance covered is about 60 kilometers (37.3 miles), of which about 25 (15.5 miles) are in galleries; a maximum elevation of 1,245 meters (4,084.6 feet) is attained in the middle of the tunnel.

The northern approach, from Frutigen to Kandersteg, will not necessitate great labor, and will be easily constructed except in the locality of Buhlstutz, where it will describe a double curve, and will farther climb by means of a helical tunnel consisting of three superimposed circles. Then, except for two galleries for protection against avalanches, the way continues under the open sky and over little-disturbed ground. The southern inclined plane, on the contrary, will not only be very much longer, but will traverse very unsettled ground, susceptible to earthquakes and to serious and dangerous cataclysms such as avalanches and landslips. To avoid these inconveniences the way passes through eleven tunnels with a total length of 5,000 meters (3.1 miles) and crosses twelve bridges and viaducts. As far as possible the rails are laid on the rock or trust to a slope of masonry resting on the mountain side. Numerous works of defense have had to be carried out to prevent the slides of earth and to obstruct, deviate, and dam the overturbulent torrents. Considerable work for the prevention or deviation of avalanches has been undertaken. The causes favoring the formation of avalanches are generally the smoothness and the inclination of the denuded pieces of ground; the beds of snow commence to slide on the smooth slope, and meeting no obstacles, fall down as avalanches. It has been found that a system of walls and trenches will checkmate the sliding tendencies of the snow. This is what has been done at Loetschberg, and it has been proved beyond doubt that by this ingenious means avalanches need no longer be dreaded.

The length of the tunnel from one entrance to the other had been calculated to be about 13,735 meters (8.55 miles). But after the unexpected eruption of water on July 24th, 1908, when the tunnel had advanced 2,675 meters (1.66 miles), causing the death of twenty-five miners and encroaching upon the progress of the gallery for 1,500 meters (4,921 feet), the axis of the tunnel was deviated and its length augmented. At a distance of 1,203 meters (3,947 feet) the old gallery has been abandoned and walled up, leaving only a passage for the drainage of the water. From this point the new line turns to the left in a curve of 1,100 meters (3,609 feet) radius; then comes a straight section of 1,658 meters (5,440 feet), then it turns to the right in another curve of an identical radius for 1,118 meters (3,669 feet), rejoining the old line at 10,529 meters (6.73 miles) by a last curve of 321 meters (1,050 feet). The deviation line has a length of 9,526 meters (5.92 miles) and adds another 801 meters (2,628 feet) to the length of the tunnel, which will now have a total length of 14,536 meters (9.03 miles) instead of the 13,735 meters (8.55 miles) originally provided for. This complication of the line will necessitate frequent examinations, thus retarding the excavation and the completion of the tunnel. Like the Simplon, the tunnel will be vaulted all the way. So far two-thirds have been excavated and the masonry for half is completed. The actual figures given in the official report just to hand state that up to July 31st, 5,420 meters (3.37 miles) had been bored on the north side and 5,860 meters (3.64 miles) on the south side, giving a total of 11,280 meters (7.01 miles) out of the 14,536 (9.03 miles) to be bored. Only a very short section now remains to be bored by what are technically called the "galéries d'avancement"—narrow tunnels—which are widened by other gangs of workmen following the first pioneers. The engineers have experienced such extraordinary difficulties at one section that the old tunnel has been left (see panoramic view) and a new one out of alignment with the rest of the tunnel has been constructed. No further obstacle has interrupted the progress of the work, which will probably be finished on the date fixed, September 1st, 1911.

The method of excavation is identical with that followed in the case of the Simplon, but instead of the Brandt perforations by hydraulic pressure compressed air is used by means of the Ingersoll and Meyer systems. The drills are cut in the shape of a +. Work has been carried out simultaneously in the advanced galleries and in the enlarged section of the tunnel. The mean advance for each day is about 10 meters (32.81 feet), allowing for respites, interruptions, and unforeseen difficulties.

In two years at the latest this colossal enterprise will be finished and the new line inaugurated.

THE MEYER BORING MACHINE, DRIVEN BY COMPRESSED AIR, IS USED FOR PIERCING THE LOETSCHBERG TUNNEL.

* The Sphere.

SAFETY APPLIANCES ON SUBMARINES

By Andrew Lewis.

Ever since submarines were first introduced, brainy men have been at work devising methods by which dangers to their crews can be reduced to a minimum. Those who are used to serving in these deadly little craft will tell you that these dangers are not as great as is usually imagined, and that the loss of life from accidents has really been comparatively small.

The two great dangers are collision and explosion, and special attention has been given to methods that will prevent loss of life in case of accident from these two sources.

When the submarine is submerged, it is really half blind; for the periscope is only a makeshift eye. But even this has been greatly improved. Formerly the lens in use only allowed half the horizon to be examined unless the periscope was turned around. It could, therefore, happen that a ship might come up unnoticed and strike the submarine before it could dive into safety. It was in this manner that the British "A 1" was sunk by the "Berwick Castle." Now, however a new lens has been devised which gives a complete view all around, so that an approaching vessel can be seen from whatever quarter it comes.

Another danger is escaping gasoline, which may lead to an explosion. By the regulations the engine must be stopped as soon as an escape is noticed; bad accidents being caused a few years ago by neglect of this precaution. In the early days of submarines, mice were kept on board, as they were affected by an escape of gasoline long before the crew noticed it. They would run about, squeak violently, and show every sign of distress. But now the engines make so much noise that their squeaking would not be noticed. At present a more scientific method of detecting the escape of noxious fumes is in use. Two engineers employed at Portsmouth have invented an apparatus that registers the escape of gasoline or other gases, coming into action long before sufficient can have escaped to form an explosive mixture. By an ingenious contrivance a red light is substituted for a white one and a bell is rung when there is a leakage of gas.

Sometimes sea-water will penetrate into the accumulators—a very serious danger, as chlorine is thereby evolved which may suffocate the crew. The "A 4" had a very narrow escape in this way, but fortunately one of the attending ships was near and opened the hatch as soon as it was seen that something was wrong. Thanks to another invention, however, this deadly gas is now rendered comparatively harmless.

A safety helmet somewhat resembling that worn in mine explosions, is now provided. Attached to a watertight canvas jacket that straps round the waist is a big helmet with a glass front, not unlike that of the ordinary diver. Just below the front of this is a magazine containing a special substance called "oxylithe," which has the power of giving off oxygen and absorbing the carbonic acid in the air when it comes in contact with water. In this manner the wearer of the helmet has always a good supply of air to breathe, so that in case of the evolution of chlorine the crew would hastily don these jackets.

The helmets have still another use; for, being full of air, they serve as life buoys. Thus, in the event of a submarine being struck by a passing ship and punctured, these jackets would be put on at once. Then the hatch could be opened and the men would float to the surface. However, if the hole were large, the water would pour in so quickly that there would be no time to get into these. But British inventive genius has not found this difficulty too great to solve, and now all submarines are being fitted with a very simple little safety device.

As soon as a submarine leaks, the water fills the bottom and pushes the air to the top, where a certain quantity is always held in any odd little corner near the ceiling. Therefore, thin steel partitions, depending a foot or two from the ceiling, in places where it slopes or forms corners, are being fitted in order to form air traps in different parts of the interior. Thus, when a bad leak occurs, quickly filling the submarine with water, the air is pressed into these traps. The crew immediately seize their helmets and stand with their heads and shoulders above the water in the air traps, so that they can breathe while putting on the safety dress.

Another invention that has been tried in one or two of the underwater craft consists of a long flexible tube attached to the outside. At one end is a float, while the other communicates with the interior. In the event of an accident, this tube is liberated and is at once borne to the surface by the float, to which is attached a flare to give notice to any ship near at hand; until the submarine is raised, the crew can breathe through this tube, or food might even be passed down.

At least one American vessel is fitted with a door

through which the crew can escape if necessary. This door opens into a chamber which, in its turn, communicates with an airlock. If it is desired to leave the submarine, a diving dress is donned and the airlock entered. The door communicating with the interior of the vessel is closed, and then the diver goes into the outer compartment, closing the door of the airlock after him. Water is then allowed to enter, and, when it is full, he merely opens the door and steps out. The door is then closed and the water pumped out again, so that others can follow.—International Marine Engineering.

THE STATUS OF PROCESS INVENTIONS.*

A PATENT LAWYER'S VIEWPOINT.

BY E. D. SEWALL.

Concluded from Supplement No. 1813, Page 219.

THE PHILOSOPHY OF PROCESS INVENTIONS.

Three classes of inventions corresponding exactly with the intellectual laws of invention have always been expressly recognized in the United States statutes. These three classes are (1) the product or thing produced—represented by the words "manufacture" and "composition of matter," (2) the way or method of producing the product, or of accomplishing an industrial effect (when the product of the process is not a concrete thing, as a form of energy), represented by the word "art," (3) the instrument used to aid in practicing the "art," represented by the word "machine."

The order of inventive conception is (1) the product, (2) the process of making the product, (3) the machine for carrying out the process. In answer to the question "What shall I make?" the inventor conceives the product; to the question "How shall I make it?" he conceives the process; to the question "By what means shall I practice the process?" he conceives the machine. He must have a clear notion of a product before he can devise a process of making it and must perceive clearly the process before he can build a machine to practice that process. Patents rank in value in the same order. The patent for a manufacture gives the broadest possible protection, since subject to it are all possible processes of making it. The next broadest protection is afforded by the process patent, since subject to it are all possible machines whose *modus operandi* is the process. The protection afforded by the apparatus or machine is the most limited of all. Of course a machine or apparatus may be the product desired, and the process of making that machine will then be inferior in patent value to the machine. Or the ultimate result may be an effect, not resulting in a manufacture, produced by a process carried out by the aid of a product which in turn becomes an instrument inferior in value to the process. But always, in the relation of value and rank, the process is higher than the instrument used in practicing it, and the product is higher than the process by which it was made.

Higher still than any of the three kinds of inventions—product, process, and apparatus—stand effect, result, principle, which are not inventions. In accordance with natural law and with the fundamental principles governing monopolies, principle, result, effect, cannot be monopolized. They are the property of all equally, and become known by perception, not by invention. There can be no lawful claim for an effect or principle. A claim in a patent or application for patent for an invention in any one of the three statutory classes conclusively concedes pre-knowledge of that which stands higher in rank. A claim for a product concedes pre-knowledge of the mode of using it and of the effect or results designed to be produced by its use; a claim for a process conclusively concedes pre-knowledge of the principles utilized in the process, of the product made by that process; and of all instruments the use of which is made a part of the process; a claim for an apparatus concedes previous knowledge of the process it is designed to practice.

The principles just stated are fundamental and essential to be applied in testing any alleged invention. It must also be remembered that all invention lies in the mental conception. For obvious reasons the invention is not a patentable one until it has been made potentially available to the public. But in testing any claim for the presence or absence of invention, the inventive conception must be resorted to and the rank of that conception determined.

Suppose one desired to make a hole in a metal plate. The production of the hole is the effect, not patentable. One way to attain this effect is to remove the metal by cutting it away in detail; another is by displacing the metal by forcing a punch into it; another by burning it in the presence of pure oxygen. One person might have a patent for one method, and another person a patent for another method of attaining this effect. Obviously the patent for displacing by the punch would not conflict in any way with that for oxidizing or with that for cutting the metal way in chips.

Assume that the method of chipping away the metal is adopted. As metal cannot be worked without instruments an instrument for cutting a hole by chipping away the metal has to be devised. The twist drill is conceived, which is one of several instruments that will carry out the method of cutting the hole. A method of making this drill is now sought. One conceives of making it by twisting a properly formed straight blank, another by forging spiral grooves in a round blank, another by removing metal to form spiral grooves. None of the processes conflicts with the others or derives anything from the others, but all derive something from the drill, and would infringe the drill patent. A machine is then sought that will carry out the desired method, say of removing material to form the grooves. A milling machine is designed. This should not infringe a patent for another machine which removes the metal by planing, but both would be subject to the process patent. And so process, product, and apparatus may proceed indefinitely. The metal plate with the hole in it may be a product, and also an instrument in carrying out another process; and the machine for making the drill may again stand in the relation of product to some other process.

No valid product patent can be so broad in scope as to prevent the possible allowance of other non-infringing product patents designed to secure the same effect. No valid process patent can be so broad as to hold as an infringement every other possible process patent for producing the same product. No valid machine patent can be of such scope as to close the field to other machines for carrying out the same process. By "possible" is here meant theoretically possible, as it may occur, as in the telephone invention, that the method discovered and applied is the only one. This is a fundamental truth of patent law, notwithstanding that the existing mass of patents fails to support it.

Process inventions are in general the most fundamental ones. They *are* the "useful arts." The most valuable manufactures have been known and used for years; and as ways of manufacturing essentially old products are the prime problems of manufacturing industries, it is most important to have process inventions protected.

A process is a way of attaining a result; and any process that is new, useful, and based on an inventive conception, is patentable under the law, if it is applied to "science and the useful arts." It matters not whether or not it includes "chemical" reaction or "similar elemental action," or is carried out by an automatic machine. The only conditions precedent imposed by the law are that it shall be new, useful, and an invention; and those conditions apply equally to all classes of invention.

The much discussed and much applied phrases "function of a machine," "mere mechanical process," should be dropped from consideration in determining the patentability of a process. They have no bearing on the question of invention involved in them. Process inventions should be approached in the same way as machine or article inventions.

In settling whether a defined process is patentable it must, of course, be determined that it is within the field of permissible monopolies, and if it is, then it must be ascertained, (1) if it is new, (2) if it is useful, (3) if it is an invention—nothing else. The question of utility presents little difficulty and that of novelty, none, except research into the existing art. The serious question is that of invention. In settling this, most of the negative rules applicable to machine inventions are applicable to processes, and there is no more mystery connected with the treatment of process than with the treatment of machine inventions. If the process alleged is an "aggregation" of separate processes, if it involves over an old process the mere substitution of an equivalent step, it is not patentable.

The word "mystery" was frequently applied to processes in the early days of patent monopolies. It was used in the decision of Boulton & Watt vs. Bull, above, and is a word that aptly indicates the essential quality of a patentable process. To be patentable a process must be mysterious to one who has not been informed. No process that is not mysterious, that does not include hidden steps, no process that is apparent when the result of it, or the principle involved in its practice, is considered, is patentable. The process of making a car wheel that consists in forming a wheel body of paper, and applying a steel tire thereto, is the obvious way of making the desired product, which is a paper wheel having a steel tire. The conception of the wheel came first. There was no room for further invention in the process. Merely practicing manufacturing steps that are apparent in the article made is not invention—it is mere following copy. Furthermore, a patent for such a process covers by its terms all possible ways of making the defined article and violates an axiom of the law of monopolies.

Chemical processes have been uniformly admitted patentable. What are the "similar elemental actions" that render process inventions patentable? Can anyone conceive of any acts performed on matter, gaseous, liquid, or solid, that do not take advantage of some elemental law of nature? One hammers iron into a nail, taking advantage of the laws of cohesion and malleability. One sifts ashes aided by the law of gravity, one folds paper, taking advantage of the property of flexibility. But whether elemental action is involved or not is wholly immaterial; such action probably always is involved. The sole thing to be considered is whether there is a "mystery" which this process has unraveled.

Every machine and every instrument operates to practice some process in whole or in part. The fact that that process is ancient and common makes it none the less a process. The process of smoothing wood by planing, or shaping iron by hammering, is still a process under the patent laws, although an ancient one. A process that is carried out by an automatic machine may be no less an invention than one carried out by hand or by chemical reagents.

A pair of revoluble rolls may manufacture sheet iron, if hot iron billets be passed between them, make breakfast food of corn or wheat, squeeze water out of wet clothing, flatten bent plates, calender paper, roll plate glass, etc. The function of these rolls is not to make sheet iron, crack wheat, wring clothes, or calender paper. It would hardly be sensible to reject a process of preparing grain for food by passing it between metal rolls, on the ground that the process is the function of the machine, for it is no more the function of the rolls to crush wheat than to make sheet iron or wring clothes. In approaching a question of this sort, instead of concluding at once that the process is the mere function of the machine, it should be considered in accordance with the fundamental principles. First, the result is disintegrated wheat in flaky form, conclusively old as a conception. The process of producing it by applying pressure sufficient to break down its resistance and flatten the grain, is disclaimed and conceded to the public. The rolls as a piece of mechanism are disclaimed. Their capability of applying pressure must be conceded as known. Was there then any invention in using a known pressure applying instrument, for carrying out a presumptively known process of flaking wheat by applying pressure?

Such a question is always one of invention. Some things cannot be done by hand. Gases cannot be confined without instrumentalities, and metals cannot be shaped by the fingers. Instruments are usually necessary to the practice of processes. A claim for a process practiced by a particular instrument as a rule does not define the real invention; but it is conceivable that the use of a particular instrumentality for practicing a process may be of the essence of the invention, or that a new process may be devised for operating an old machine. Denial of validity of process inventions by allegations that they are the mere functions of a machine would better give place to treatment by considering the novelty and utility in the abstract process or series of steps as a mental conception divested from any instrumentalities, and then, presuming the abstract process to be disclaimed, considering whether there was any invention in selecting the stated instruments to aid in practicing it.

* Machinery.

THE REGNARD AEROPLANE.

AUTOMATIC STABILITY OF FLYING MACHINES BY MEANS OF THE GYROSCOPE.

BY PAUL F. MOTTELAY.

The foreign press has of late devoted much more than ordinary space to the comparatively recent applications of that singularly curious and very attractive, and as yet but imperfectly understood, form of spinning top called the gyroscope. And, it must be admitted that, in face of its many known applications, general interest in it has lately been awakened mainly through the widespread advertising of the very satisfactory results claimed to have been obtained, by its means, in securing the stability of very heavy railroad carriages on a monorail, as well as in lessening very materially the rolling and pitching of sea-craft; results which naturally appeal directly and strongly to the general public.

It may be stated here, that since reports made of the first satisfactory industrial application of the gyroscope during the year 1870, the progress achieved in its profitable use has indeed been comparatively slow. Always a source of speculation, it has, in turn, been applied, more or less effectively, for securing much needed stability mainly to the Beauchamp hydraulic turret, the Obry torpedo, the Brennan, Scherl, and Froelich monorails, the rifled projectiles, and to Schlick's ship-rolling extinctor; but, if present indications, through numerous patents lately issued here and elsewhere, are a guide, in connection with well-substantiated reports of experiments, none of the above-named applications is likely to attract as much attention as is vouchsafed in its application to the aeroplane.

In a very able historical dissertation on the stability of flying machines, given not long since, it was truly stated that this all important requisite of aeroplanes was the one upon which nearly all manufacturers appeared the least informed. The distinction between stability and equilibrium apparently does not seem by them to have been well borne in mind. Briefly stated, an aeroplane is in equilibrium when traveling at a uniform rate of speed, and it is necessary for stability that, if the aeroplane is not in equilibrium and is not moving uniformly, it shall tend toward a center of equilibrium, also that any oscillatory motion shall have a positive modulus of decay or coefficient of subsidence. A thorough study of the different forms of flying machines lately made by a close observer showed to his satisfaction that the only two types of machines likely, under ordinary conditions, to prove stable are the automatic single-surface glider and the balanced glider. The first, as he expressed it, relies for its longitudinal stability on the variation of the center of pressure with the angle of attack, while the second, which, by the way, is the type that received the attention of the late much lamented Captain Ferber, relies on the variation in altitude of a balancer or tail surface. In each case, a torque should come into existenc to bring the glider back to its original position.

With these types however, as they now stand, a very severe squall is likely to prove disastrous. The righting of the machine cannot be made rapidly enough, for too much is still demanded of the pilot's attention in the direction of motors, etc. The better to centralize all the attention necessary to the latter, the aviator must feel sure of the equilibrium of the entire apparatus. This has been tried by various agencies, but yet the recent numerous and very severe accidents show that many avail but little. There must necessarily be an automatic adjustment to secure the equilibrium of all the planes, and we are glad to say that after many trials this appears to have been secured by Mr. Paul Regnard, a well-known French engineer, who has represented his country at different exhibitions and who was the first president of the Société Française de Navigation Aérienne.

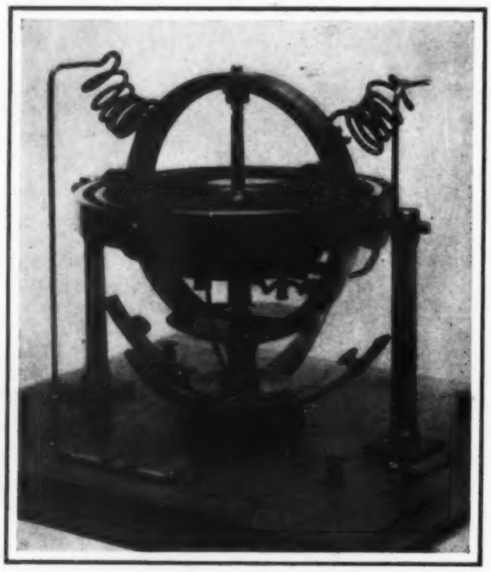


FIG. 6.—THE GYROSCOPE AND ITS CARDAN SUSPENSION SHOWING THE STUDS, PLATES, ETC.

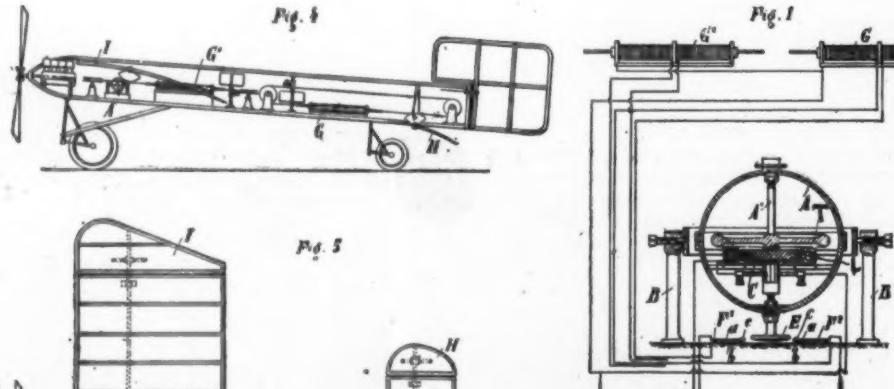
Herein is shown an illustration of the main portion of his apparatus (Fig. 3) as well as a much-reduced model of the aeroplane itself which was, not long since, submitted to both the Académie des Sciences and the French Aero Club, illustrating its working by a very happy combination of electricity and of the gyroscope. The small and comparatively light gyroscope necessary is not directly employed to insure stability; as will be seen it serves merely to transmit at any given moment the current necessary to insure both longitudinal and transversal equilibrium.

The main part of the apparatus shown in Fig. 1 is a gyroscope which is located at a suitable place on the aeroplane, and is supported in a gimbal frame (Cardan joint) upon two posts *B B*, in such a manner as to secure its complete independence and freedom, as to direction with reference to its supports. Within the revolving mass of this gyroscope is the arm *A* and the ring armature *C* of a small dynamo machine with which it is directly coupled at its lowermost extremity.

The stationary field magnet *L* of the dynamo is also of the ring type and stands in the same plane as the armature which is therein inclosed. By means of the current taken from a battery of eight or ten cells, similar to those employed on motor vehicles, the flywheel is set and is maintained in rotation at a speed of about 10,000 revolutions per minute. It will adopt under the influence of such rotation, according to the well-known laws of mechanics, an invariable, permanent, direction parallel to the plane of the space wherein it is swung (the horizontal plane in the present case), and owing to its mode of suspension will take with reference to the aeroplane all the relative positions corresponding to the inclinations assumed by the latter. For, whether the aeroplane inclines to the right or to the left, forward or backward, the stud *E*, rigidly connected with the gyroscope, which continues to rotate in a horizontal plane, must necessarily establish electric contacts *F* according to the movements imparted to the apparatus, each of said contacts being alternately employed by the aviator for controlling and steadying, as he readily can do, the movements of one or more sections of the aeroplane.

Each of these contacts *F* can be made—as shown, by way of example, in Figs. 1 and 2—of the superposed conducting plates *a* and *b*, the upper plate *a* having a projection *c* upon which will in turn press the stud *E*, whose inferior convex-shaped surface will always instantly meet the center of rotation of the gyroscope. It is needless adding that these contacts could be obtained in many different ways.

Under all circumstances, in whatever direction the aeroplane inclines, the stud *E*, whose axis is always vertical, as shown above, presses momentarily on the plate *a*; the latter then comes into contact with the plate *b*, and the circuit thus established can be used for specially controlling any particular one or more of the balancing organs of the aeroplane. This could, of course, be done by small electric winches, but in the



FIGS. 1, 2, 4, AND 5.—SIDE AND PLAN VIEWS OF AEROPLANE AND DETAILS OF GYROSCOPE.

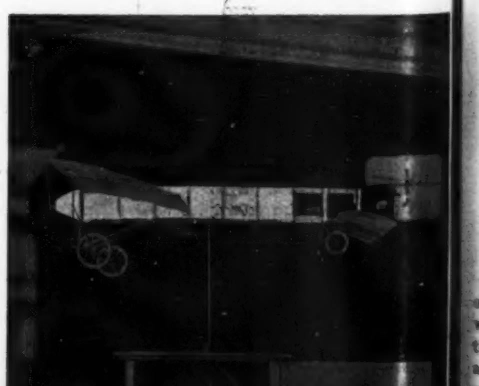


FIG. 3.—SHOWING REDUCED MODEL OF AEROPLANE. ALSO MAIN PORTION OF THE REGNARD APPARATUS.

present case it is effected by means of soft iron plungers entering a solenoid, as described in Figs. 1, 4, and 5. Admitting, as in the illustrations, that the stud E is freely movable between the four contacts, say two F^1 and F^2 for the longitudinal balance, and the other two, F^3 and F^4, for the lateral balance, of the apparatus, two solenoids, G, G^1 will be required, each being connected with the two corresponding contacts for obtaining any desired equilibrium.

Should, for example, a squall, any strong gust of wind, or other circumstance, cause the front of the apparatus to point downward, the stud E will instantly make the contact F^1, and the rear wings H of the aeroplane (Figs. 4 and 5) will be inclined forward, operated as they are in this case by the solenoid G through the medium of a roller and a sector. If, on the other hand, the front end of the apparatus suddenly rises, the wings H will then be elevated through the contact F^2 and the solenoid G^1. The whole apparatus is thus restored to its normal position.

In the event of the apparatus inclining transversely to one side or the other, the contacts F^3 and F^4, in conjunction with the solenoid G^1, will re-establish the equilibrium, either through the combined movement of the wings I and I^1, which are operating in opposite directions, or through the warping of the planes of the apparatus.

In Fig. 6 is an enlarged view showing to still better advantage the gyroscope and Cardan suspension, the stud, plates, etc.

A 1,000-MILE WIRELESS STATION.—II.*

HOW TO CONSTRUCT THE RECEIVING STATION.

BY EDWARD H. GUILFORD.

Continued from Supplement No. 1803, Page 54.

ESPECIAL care must be used in constructing the transmitting instruments, for high frequency, high potential currents are now to be dealt with, and unless the insulation is everywhere perfect leakages are sure to occur. As far as possible, fiber or hard rubber should be used wherever any part of the secondary circuit comes in contact with anything. All connections should be of low resistance in order to prevent any damping effect in the production of the wave. All sharp points should be avoided in order that no brush discharges shall occur. It is only by paying attention to these little details that a transmitting set may be brought up to its full efficiency.

The theory of the production and transmission of wireless signals is this, roughly speaking: By means of an induction coil or a transformer the initial voltage is stepped up until it reaches a very high potential, usually in the neighborhood of 20,000 volts. At this high voltage the electricity is caused to jump across a spark-gap which is in series with the aerial and ground wires. In discharging across the gap oscillations or waves are set up, and it is these same waves which travel through space to the distant station and are there caught by means of another aerial and ground wire. In actual practice more instruments than those mentioned above are used. Referring to the wiring diagram, C is a condenser which is charged by the secondary of the transformer. The spark which now occurs at the spark gap, S, is the discharge of the condenser. The helix, H, is inserted in order that the period of oscillation of the circuit composed of the condenser, the spark gap, and part of the helix, may be tuned to the circuit composed of the aerial, a portion of the helix, and the ground. This tuning is accomplished by means of two variable contacts. Sometimes an oscillation transformer is inserted in the circuit in place of the helix. Its function is, however, essentially the same as that of the helix.

The transformer is perhaps the most difficult to make of all the transmitting instruments. If the reader does not care to make his own transformer it may be purchased from any one of a number of reliable companies. In case some other transformer or even an induction coil is used, it may be stated that the rest of the instruments described below will work efficiently with any amount of power up to 1 kilowatt. The output of the transformer described in this article is rated at ½ kilowatt, but it will actually be found to give much more than that amount of power. By means of the impedance coil, also described below, it is possible to secure a wide range of power between the given limits. This is an important thing, for needless interference may be avoided by using small power whenever possible.

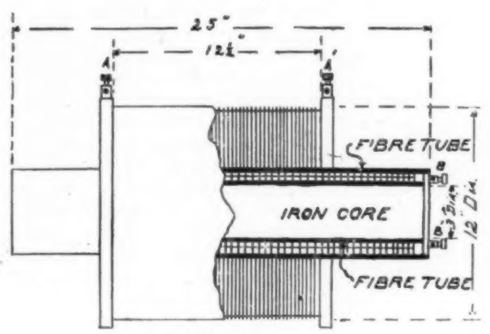


FIG. 1

The core of the transformer (see Fig. 1) is composed of a number of soft Swedish iron wires (No. 24 in size), and is made in the shape of a bundle 24 inches long, and 3 inches in diameter. This wire may be purchased already cut to length. It should be annealed by heating it to a white heat and then cooling it very slowly. After the core has been annealed it should be packed in a pasteboard or fiber tube, ⅛ inch thick, 3 inches inside diameter, and 24 inches long. This tube will keep the core in compact mass and at the same time offer a smooth surface upon which the primary of the transformer may be wound.

The primary winding consists of two layers of No. 14 double insulated copper magnet wire there being about 150 turns in each layer. The wire should be double cotton-covered and should be further insulated by treating it to a bath of melted paraffin wax. When both layers are wound on the core, the core with its winding should be slipped in a second fiber or hard rubber tube of such a diameter that a close fit will be effected, and the whole should be soaked in melted paraffin, so that when cooled all the air will be excluded from the tube. This second tube, which is placed about the core (see Fig. 1), should be at least ¼ inch thick and of such a length that it will project ½ inch over each end of the core itself. Neat ebonite or fiber plugs may be fitted in the ends of this tube, and on one of the plugs binding posts may be fixed to which are connected the two terminals of the primary.

The secondary of the transformer may be wound in 50 sections, each section to be ¼ inch thick. About 18 pounds of No. 32 B. & S. gage, single cotton-covered magnet wire will be needed. The sections are made and wound by the following method: 100 cardboard disks are cut from cardboard stock 1/32 inch thick. These disks (see Fig. 2, B) are 12 inches outside diameter and each one has a hole cut in its center so that the disk will just fit over the outside tube of the completed primary. Each disk is soaked in melted paraffin and then allowed to cool. A winding form is made according to Fig. 2, C, of sheet brass or sheet tin, the core, D, being made of a disk of wood one edge of which is of larger diameter than the other. This method of construction will enable the user to slip the completed sections out of the form very easily. The side, E, may be removed by unscrewing the lock nut, F. The form may be rotated by hand or by placing it in a lathe. A melted paraffin bath is next made. This is simply a pan of paraffin which is kept in a liquid state by means of a flame underneath the pan. A small spool is fastened at the bottom of the pan, so that the secondary wire must pass through the bath before being wound in the section (see Fig. 2, A). The sections are now ready to be wound. A cardboard disk, previously treated with paraffin as directed, is placed in each side of the winding machine, and a

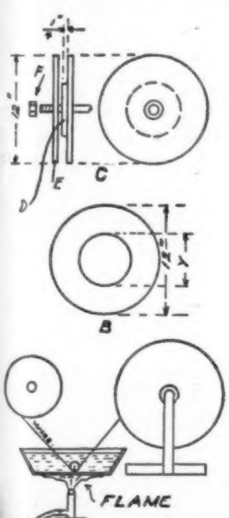


FIG. 2

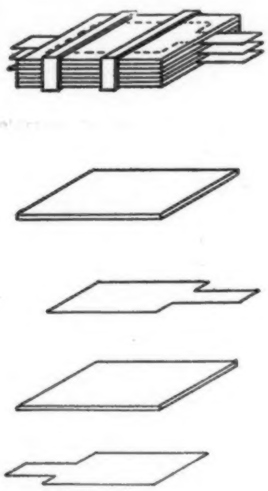


FIG. 3

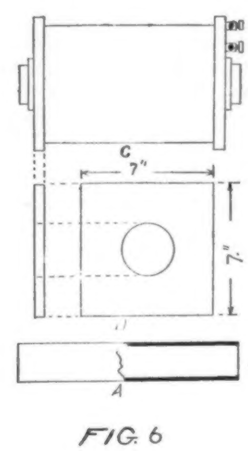


FIG. 6

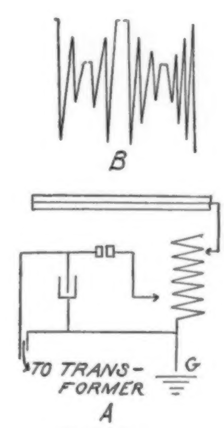


FIG. 8

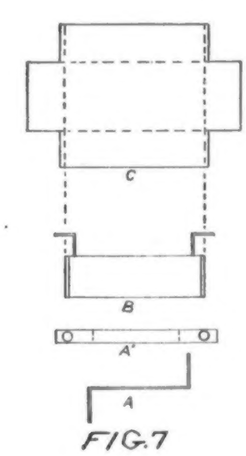


FIG. 7

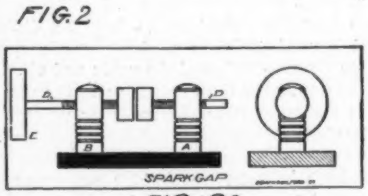


FIG. 3A

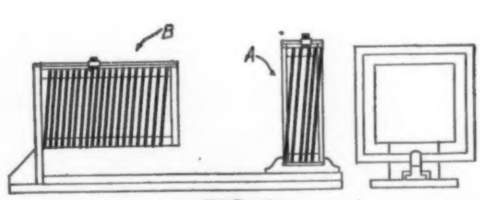


FIG 4.

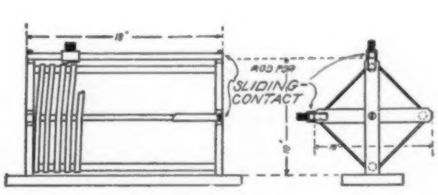


FIG. 5

* Electrician and Mechanic.

strip of paper is wound around the core, *D*, Fig. 2, *C*. The thickness from outside to outside of each section should not be more than ¼ inch. The wire should now be wound off the reel upon which it was purchased, through the paraffin bath, and thence to the section in the winding form. Each section should be wound full. The distance between the winding machine and the bath should be as short as possible in order that the paraffin may not cool before the wire is in its place in the section. Too much paraffin on the wire should be avoided or the proper amount of wire cannot be wound on the section. The proper amount of paraffin is that which will just saturate the insulation of the wire, and may be had by keeping the bath very hot. Each section when completely wound should have from 700 to 900 turns of wire in it. After winding, the sections should be assembled in bunches of 10, soaked in paraffin and then cooled under pressure. Each section is connected to its neighbor in such a manner that the outer terminals of two are joined, the inner terminals of the next two, and so on, the wire all the time running the same direction. (See Fig. 8, *B*.)

When the secondary is in place (see Fig. 1), the transformer may be immersed in oil, or neat wooden disks can be fastened at each end, a cover of hard sheet rubber wound around the outside, and the completed transformer set in a cradle. It is recommended, however, that the transformer be placed in a tank of oil.

For the spark-gap metal, steel is one of the best metals to use, as I have found from experiments that that metal has the least tendency to cause arcing, and the faces of the spark gap, when made of it, wear down very evenly. The two standards, *A* and *B* (Fig. 3 *A*), are made of ¾ inch brass stock, and may be ornamented in any way the maker may choose. The chief requirements are that the planes of their bases should be perfectly flat and perpendicular to the axis, and the holes for the rods, *DD*, must be bored exactly at right angles to the axis of the standard. If bored otherwise the faces of the gap will not be parallel. The rods, *DD*, are 4 inches long and threaded for 3 inches on one end, and ½ inch on the other; 30 threads to the inch should be used. The handles, *EE*, are made of fiber, ¾ inch thick by 3 inches in diameter, and their periphery is knurled. Care must be exercised that the rods, *DD*, do not project through the handles, for if they do, the user is liable to get a severe shock if he tries to adjust the gap while transmitting. Only one handle is necessary, but two of them add to the appearance of the instrument.

If full power is used, a muffler should be added to deaden the roar of the spark. This may be made of a glass or fiber tube about 2 inches in diameter, and 3 inches long, with pasteboard ends fitted in. The base for the spark gap should be made of some good insulating material, such as glass, rubber, or fiber, about 3 inches wide by 8 inches long.

A table for the approximate sizes of condensers for the second transmitting current is given below. No. 3 should be used for the transformers described in this article. It should be remembered that the figures are based upon the fact that the finest glass obtainable was used in the condensers, and that the condensers were constructed in the most careful manner. The amateur should make his condenser a little larger, if anything, than those given below:

	Kilowatts	Size of glass.	No. of panes of glass	Size of tinfoil	No. of sheets of tinfoil	No. of sections
1.	¼	8 x 10	30	6 x 8	27	3
2.	½	10 x 12	40	8 x 9	36	4
3.	1	14 x 16	50	10 x 12	45	5
4.	1½	14 x 16	75	10 x 12	70	5
5.	2	14 x 16	100	10 x 12	95	5

The condenser should be made up in sections, so as to allow variations, and also to make it easier to repair them should they break down. They are constructed of alternate sheets of glass and tinfoil. (See Fig. 3.) A pane of glass is put down, and upon it is laid a sheet of tinfoil, leaving about 1 inch margin of glass around three sides and overlapping the fourth side by about 2 inches. A pane of glass is now laid upon the tinfoil, and upon that another sheet of tinfoil, but with this difference, the overlapping end of the tinfoil lies in the opposite direction from the first sheet. Thus the sections are built up, care being taken that each section begins and ends with a pane of glass. When the tinfoil is laid on the glass, it should be stuck on with vaseline, and all the air should be rolled from under it, by means of a pencil or some similar cylinder. As each section is completed, the loose ends of tinfoil should be rolled up, and a binding-post screw pushed through them. Suitable washers should be fitted to the screw so that it will not pull out. The screw should be fastened in position before the binding-post is screwed on, by winding two or three turns of tape around the section, slotting each turn so that the screw will project straight through the tape.

The sections may now be immersed in a tank of linseed oil for further insulation. A bread-box—if it does not leak—makes an excellent tank, or one can be made from zinc according to Fig. 7, *B* and *C*. Each tank should hold four sections. The sections might, instead of the above method, be cast in paraffin. In either case, the important requirement is that *all* air be driven out from between the plates of glass. The lugs, Figs. 7*A*, *A'* are made of sheet brass, and are connected to the condensers in the tank so that they project up over the edge. They are used to make good connections with the condenser.

The helix should be wound on a frame, made of fiber or hard rubber, although wood will do if thoroughly dried and shellacked. (See drawing of helix, Fig. 5.) Strip copper or brass is much better, weight for weight, than copper or brass wire, the reason being that oscillations travel on the surface only. Therefore, to reduce resistance, the surfaces of connections and wiring in the secondary transmitting circuit should be as large as possible. Another point that should be noticed is that the formula for the determination of inductance includes the distance between successive turns of wire on the helix, as the denominator of a fraction. Therefore, the larger the distance between turns, the smaller will the amount of inductance become. As the object is to secure as large an amount of inductance as is possible, the distance between the turns of wire on the helix should be as small as they can possibly be made. Of course, the distance could be so small that sparking would occur between each successive turn; but this distance in the case of a ½ kilowatt of energy would not be more than ¼ inch. Two contacts should be provided for the helix, either sliders, as is shown in the drawing, or brass clips with a wire soldered to them leading to a binding post.

An impedance coil is necessary if the coil is to be operated on the regular 110 volt 60 cycle, alternating current, for the flow of current through the primary of the transformer must be regulated so that the house lights will not blink. This impedance coil (see Fig. 6, *C*) is simply a large core of soft iron around which is wound a number of turns of insulated copper wire. The core, Fig. 6, *A*, is 3 inches in diameter and 15 inches long. It is made similar to the core for the transformer, of a number of Swedish soft iron wires, and is forced in a tube of fiber which has an inside diameter of 3 inches. The copper wire is No. 14 double cotton-covered, and is wound on a reel made by fitting square ends to a tube which will just slip over the tube containing the core. About 12 to 15 pounds of wire will be used. The terminals of the wire are connected to two binding posts on one end of the coil. This impedance is used by connecting it in series with the primary of the transformer. By pulling the core out the current is increased, and conversely by pushing it in the current is decreased.

The oscillation transformer, Fig. 4, is a stationary frame of inductance, *B*, and a movable frame, *A*, of inductance. Upon a frame of fiber or hard rubber 12 inches square and 5 inches long, four or five turns of copper or brass strip ½ inch or ¾ inch is wound. The turns should be ¼ inch apart. But one variable contact is necessary. The variable contact may be seen at the top of each frame in Fig. 4. The secondary is wound on a fiber frame 9 inches square and 15 inches long. Copper or brass strip is used, ¼ inch to ¾ inch wide. But one sliding contact is necessary on the secondary. The outside end of each frame of wire is left disconnected, but the inside end of each is connected to a large binding-post at the end of the frame.

The key to break the primary current is the regular Morse telegraph key, but if a heavy current is used the key should have extra large platinum contacts.

(To be continued.)

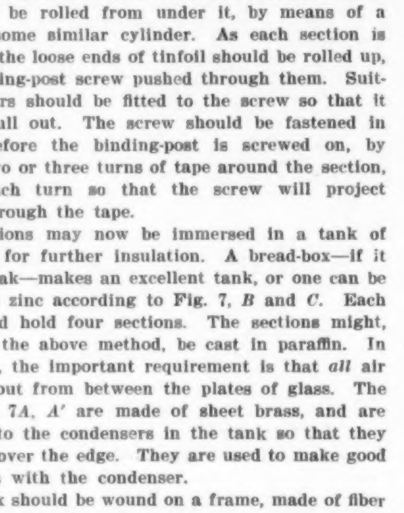
APPARATUS FOR DETERMINING THE EXPOSURE OF PROJECTED BUILDINGS AND GROUNDS TO THE SUN'S RAYS.

ALTHOUGH it appears self-evident that every room of a dwelling should receive sufficient sunlight and fresh air for the use to which the room is to be put, this fundamental principle of construction is often disregarded. In designing a house, the uses of the various rooms should be borne in mind. The nursery, which cannot have too much light and heat, should be placed on the south side, the living room on the south or east, the bedrooms on the east, the study and dining room on the north, the kitchen, storeroom and toilets on the north or northeast, and the stairs on the remaining side, the west.

Even in the construction of a detached, one-family house it is not always possible to carry out this scheme, owing to the shape and position of the lot and other considerations, such as the desirability of placing the study and the bedrooms on the quietest side, away from the street. In every case, however, it is very desirable to know, before commencing to build, exactly how the sun's rays will strike the house at various seasons and hours. This is especially important in the case of a block of houses, for the shadows cast by one part of the structure upon another cannot be foreseen with accuracy. In laying out parks and gardens, also, the direction of the sun's rays should receive careful consideration.

Prof. Eugen Koenig has devised and patented a simple apparatus for determining the direction of incidence of the sun's rays upon buildings and parks at every season of the year and every hour of the day, as well as the shadows cast by the various parts of the construction. The apparatus consists essentially of a circular table, surrounded by a hoop of iron and partially surrounded by a semicircular arc.

The hoop represents the equator and is inclined to the table at an angle equal to the latitude of the place. It is divided into 24 equal parts by hour marks and is capable of rotation in its own plane. The semicircular arc is pivoted at its extremities and follows the motion of the hoop, remaining always perpendicular to the plane of the latter. An incandescent electric lamp, representing the sun, is attached to the arc and can be moved along it. A model of the projected buildings and grounds, constructed on a scale of 1 to 500 or 1,000, is placed on the table, with its east and west lines parallel to the plane of the hoop. If the lamp is then set on the arc at a distance above or below the hoop equal to the north or south declination of the sun on any day of the year, and the hoop is turned to any hour, the illumination of the model by the lamp will exactly represent the illumination of the finished construction by the sun at that hour of that day. The apparatus may also be used for demonstrating the apparent annual and diurnal motions of the sun.—Umschau.



APPARATUS FOR DETERMINING THE DIRECTION IN WHICH THE SUN'S RAYS FALL ON PROJECTED BUILDINGS.

OIL USED IN MAKING PAPER UMBRELLAS.

THE vegetable oil used in making umbrellas in Japan is pressed out of the seeds of Perilla ocimoides, an annual plant which resembles Perilla pekinensis.

This oil is made in the Tshcigi, Saitama, Chiba, Miyagi, and Ibaraki prefectures. These prefectures are famous for the production of the seeds and oil. Sandy ground is favored for the cultivation of the plant and the oil is extracted from the seeds by presses. The yield of seeds is estimated at 20 bushels per acre. The annual production throughout Japan amounts to 300,000 to 350,000 bushels, from which over a gallon of oil per bushel is extracted, according to Japanese statistical returns. The retail price of the oil is 35 cents per sho (one sho being 0.4766 of a gallon).

The oil, before being used, is boiled and then cooled until it can be applied by hand to umbrellas with a piece of cloth or waste. No machinery or tools are used in applying the oil. When the oiling is completed the umbrellas are exposed in the sun for about five hours.

This oil is also used in making paper lanterns, oil paper, and artificial leather. It is also used in preparing materials for making printing ink, paints, varnish, and lacquer.—From Consul-General Thomas Sammons, Yokohama.

Underground leaks discovered and stopped by the pitometer division of the Water Department, Washington, D. C., for the fiscal year ended June 30th, are said to have saved more than 6,000,000 gallons per day, or one-tenth of the total daily consumption. Most of this waste or an average of 5,000,000 gallons daily, was due to defective service pipes leading into residences and business houses.

THE INTERNAL EAR.

EXPERIMENTS ON ITS FUNCTIONS.

BY S. S. MAXWELL.

Notwithstanding the long series of investigations beginning with Flourens early in the last century, there still remains much uncertainty as to the exact functions of the various parts of the internal ear. The arrangement of the semicircular canals in three planes practically at right angles to each other very naturally suggests an apparatus adapted to functions of equilibration and of orientation to the lines of force of gravitation, and this suggestion is strengthened by the well-known disturbances of position and of voluntary movement which follow certain injuries to the ear, as also by the subjective sensations and the nystagmus which at times accompany diseased conditions in or near the labyrinth.

The hydrostatic theory of Goltz, and the hydrodynamic theories of Mach and others, depend upon this disposition of the canals with reference to the three dimensions in space. According to these theories the sensations, or the compensatory motions, resulting from the rotation of the head around a vertical axis depend upon the excitation of structures in the ampullæ of the horizontal canals, while the sensations and motions arising from rotations in vertical planes would result from effects produced in the ampullæ of the appropriate vertical canals. These theories seemed to receive very strong experimental support from the work of Lee[1] on the ear of the shark. Lee studied and described with great accuracy the compensatory movements made by the eyes and fins when the animal is rotated about the various axes of the body. Rotation around a dorso-ventral axis in a clockwise direction causes the eyes to be turned to the left. When the animal is rotated around a longitudinal axis so as to be inclined to the right, the right eye is elevated and the left eye is depressed. If the body is turned around a transverse axis so as to incline the head downward, the two eyeballs appear to turn their visual axes so that the anterior angle of each eye is elevated and the posterior angle depressed; that is to say, the eyes are rotated backward around their visual axes. Rotation around the same axis but inclining the head upward causes the eyes to rotate forward around their visual axes. If the rotation is around an obliquely placed horizontal axis the eye movements are in a corresponding plane; for example, if the animal is held with the head inclined downward and to the right, that is, rotated in the plane of the right anterior and left posterior canals, the right eye is elevated and the left eye depressed, but both eyes are rotated backward around their visual axes. If the animal is rotated around the last mentioned axis but into such position that the head is elevated and inclined to the left, the right eye is depressed, the left eye elevated, and both are rotated forward on their visual axes.

All the above described compensatory movements tend to preserve for the eyes the positions in space which they held before the change in position which called them forth. Corresponding movements of the fins occur, and these movements are such as would when combined with the ordinary swimming motions tend to return the body to its original orientation in space. That these movements depend upon some structure in the ear had previously been proved by Loeb,[2] who found that they disappeared permanently after section of both auditory nerves.

Lee found that stimulation of the ampulla of any canal caused movements of the same kind as those brought about by rotation in the plane of that canal. Thus on excitation of the ampulla of the right anterior vertical canal the right eye was elevated and the left depressed and both were rotated backward around their visual axes. Each of the six ampullæ when stimulated gave a perfectly definite result. Both mechanical and electrical stimulation were employed. The ampullæ of the horizontal canals were noticed to be much more sensitive than those of the vertical. From these and certain other considerations Lee found support for a very minutely developed theory of the dynamic functions of the semicircular canals. Movements of the head in the plane of any canal would cause movements of the endolymph in the canal. This movement would bring about a mechanical excitation of the sensory endings in the ampulla and this excitation would tend to give rise to the appropriate compensatory motion of the eyes and fins, and presumably, to a corresponding sensation.

Lyon[3] repeated and extended these experiments on the sharks as well as on other fishes. He confirmed and emphasized Lee's observation on the extreme sensitiveness of the ampulla of the horizontal canal. He called in question, however, the correctness of Lee's work on the vertical canals. He found moreover that in some instances compensatory movements were retained after destruction of all six ampullæ. These results if confirmed are destructive to the highly developed theory of Lee, as also to the fundamental conception in the theories of Goltz, Mach, and Crum-Brown.

On account of the apparently contradictory state of the question it has seemed important that the whole matter be reinvestigated. During the present summer I have made a series of experiments on the ears of fishes, and desire at present to report a part of the results, reserving all theoretical discussion until the final publication of the completed work. While other forms were used, the sharks are best adapted to the purpose of these experiments and all the statements below are founded on observations on these fishes:

(1) I have repeated and confirmed in the main Lee's observations on the compensatory motions of the eyes resulting from rotation of the body around its various axes.

(2) Stimulation of the ampulla of an anterior vertical canal causes elevation of the eye on the stimulated side and depression of the opposite eye, both eyes being rotated backward around their visual axes. On stimulation of a posterior vertical ampulla the eye on the stimulated side is elevated, the opposite eye is depressed, and both eyes rotate forward on their visual axes. Excitation of a horizontal ampulla causes movement of both eyes in a horizontal plane and away from the stimulated side. Each of the six ampullæ when excited gives rise to a perfectly definite movement. This movement is not accurately described as "in the plane of the canal," but is a movement of the same sort as that called forth by rotation of the animal in the plane of the canal. These results were obtained both by electrical and mechanical stimulation, and, so far as stated above, confirm the work of Lee.

(3) After removal of all four ampullæ of the vertical canals all the compensatory movements resulting from rotation around the horizontal axes of the body, both longitudinal and transverse, are retained. There seems to be little or no diminution in the strength of these movements. On the other hand, the movements in a horizontal plane on rotation around a dorso-ventral axis are at first entirely absent and are regained slowly if at all after removal of the vertical ampullæ. Nevertheless in the animals so operated, the horizontal ampullæ continue to be as sensitive as before to electrical and mechanical stimulation, *the lightest touch still producing eye movements in a horizontal plane and away from the stimulated side.*

(4) The vestibule was opened and the ear sand was carefully and completely wiped out. The cavity was then tightly packed with absorbent cotton wet with sea water. After this treatment the compensatory movements were affected in a way almost entirely similar to the result of removing the four vertical ampullæ; that is to say, the movements normally produced by rotation around a dorso-ventral axis were absent or greatly reduced, while the other compensatory movements were retained.

[1] Lee, Journal of Physiology, Vol. 15, p. 311, 1893, and Vol. 17, p. 192, 1894.

[2] Loeb, Archiv. f. d. gesammte Physiologie, Vol. 49, p. 187, 1891, and Vol. 50, p. 66, 1891.

[3] Lyon, American Journal of Physiology, Vol. 3, p. 86, 1899.

DECREASED MORTALITY FROM CONSUMPTION.

While the total number, 81,720, of deaths from tuberculosis in 1909 was greater than for any preceding year and exceeded by 3,341 the number, 78,289, compiled for 1908, the death rate, in the Census Bureau's death registration States and cities, showed a decline from 173.9 in 1908 to 167.5 per 100,000 estimated population in 1909, as reported in the forthcoming Census Bureau bulletin on mortality statistics prepared by Dr. Cressy L. Wilbur, chief statistician for vital statistics, and submitted to Director Durand.

The 1909 rate is the lowest on record for the census registration area, although it should be remembered that the rates for this area, to which large additions were made in 1906, 1908, and 1909, may not be strictly comparable throughout the period covered with respect to constitution of population. The addition of the new registration State of Ohio for 1909, for example, by bringing in a considerable rural population with a normally low death rate from tuberculosis, would tend to depress the death rate from this cause for the registration area as a whole.

It is remarkable, the bulletin states, that the aggregate of registration cities, which is not affected by the transfer of cities from the group of cities in non-registration States to the group of cities in registration States, shows practically the same number, 54,461, of deaths for 1909 as for 1908, which was 54,466, or a decrease of only five deaths.

Excluding Ohio, which is shown only for 1909, 11 of the 17 registration States for which data are given presented numerical decreases in deaths from tuberculosis for 1909 as compared with 1908, the largest being for New York (415) and Rhode Island (107). Deaths from tuberculosis increased in Washington (91) and California (78) among the six States showing more deaths from this cause. Among the larger cities the chief fluctuations were increases of 85 for St. Louis, Mo., 61 for Minneapolis, Minn., 58 for Toledo, Ohio, and 56 for New Haven, Conn.; significant from their small amount; while decreases of 222 occurred for New York, N. Y., 194 for Philadelphia, Pa., and 149 for New Orleans, La.

Cancer showed a much greater proportional increase in the number of deaths than tuberculosis, rising from 33,465 for 1908 to 37,562 for 1909. The death rate increased from 74.3 to 77, the latter being the highest crude death rate from cancer thus far recorded for the registration area of the United States.

It should be remembered, the bulletin points out, that cancer is one of the diseases having a peculiar age distribution for which the study of crude death rates is apt to be especially misleading; and until a careful analysis can be made of the data, with reference to the population details available after the compilation of the census of the present year, it will be wise to limit inferences to the fact that the number of deaths so reported and the crude rate from this cause show a constant tendency to increase from year to year. The probability of more accurate statement of this disease as a cause of death by attending physicians must be taken into consideration, and the fact that the saving of lives from tuberculosis and other preventable diseases of early or middle life would leave more persons subject to cancer at the cancer ages, and thus increase the total number of deaths from this cause and the crude cancer rate, although the actual incidence of the disease at the various periods of life may not have been altered materially.

The distribution of cancer according to location on the body shows little change except a diminution of the residual group due to more accurate statements of physicians. All certificates of death by cancer should state, whenever ascertainable, the site of origin of the disease.

Bamboo is regarded as the most useful plant that grows, and is made to serve the wants of the people of China and Japan in at least 500 different purposes. In China and Japan bamboo largely takes the place of iron and steel. The farmer builds his houses and fences out of it. It is the most available material for farming tools and utensils, as well as household furniture, while the tender shoots afford him a delicious and nutritious food for his table. It furnishes the laboring classes with many necessities, and supplies the rich with many luxuries. Almost every article used in the household of the Far East can be made of bamboo, and from the roots to the plumage every fiber is utilized. The poor people build their huts with bamboo poles for posts and rafters, and bind palm leaves together for walls and roofs with rattan ropes. The leaves of the bamboo are sewed together for raincoats and thatches, and are plaited into immense umbrellas to shield persons and property from the sun and the rain. The wood is split into fibers of various sizes to be woven into baskets, into window curtains, door screens, awnings, mats, and tables. The roots are carved into fantastic images, into handles for weapons and tools, lanterns and canes, and into divining blocks, to be used by sorcerers to ascertain the will of the gods. The shavings are used for stuffing beds and pillows, the small shoots for chop sticks and pipe stems. The hollow trunks are used for weapons by the police to punish offenders. Indeed, it is more difficult to find something that bamboo is not used for than to enumerate its purposes.

THE SEVENTEEN YEAR "LOCUST" OR CICADA.

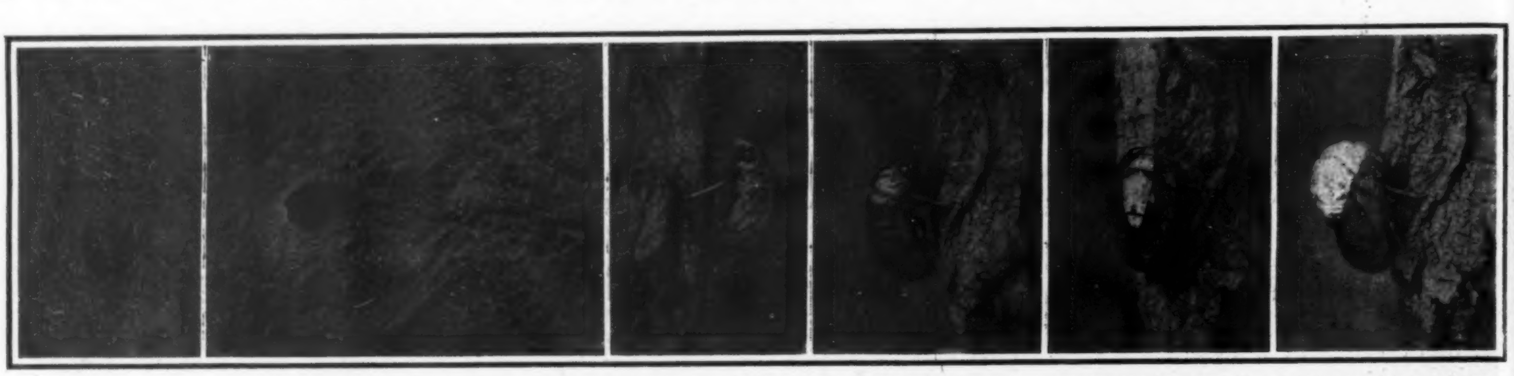
ITS METAMORPHOSIS TOLD PICTORIALLY.

THE larval life of insects is one long feast, the courses of which are marked off by the brief pauses which are occupied in molting. The larva eats and grows until its skin becomes too tight and then it casts off the outgrown garment and assumes a new and larger one. After a variable number of such changes of skin, the larva becomes a pupa or chrysalis, which is motionless or more or less active, according to the class to which the insect belongs. During the pupal stage the transformation to the adult condition takes place beneath the tough skin of the pupa. One day this skin, too, is cast off and the perfect insect appears. Its growth is finished and its adult life is occupied almost entirely in reproducing its species, the males and females, in most instances, dying soon after their respective parts of the work have been accomplished.

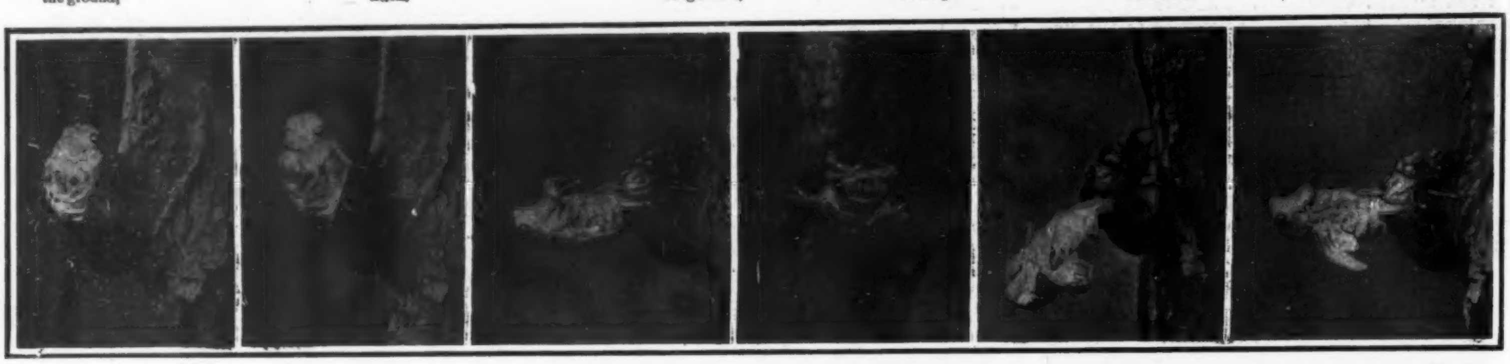
In most insects the larval life, and, indeed, the whole life of the individual is comprised within a few weeks, but there are some very notable exceptions to this rule. The larval life of the day fly extends over two or three years, that of the cockchafer or May beetle over three or four years.

Still greater longevity is enjoyed by an American species of cicada, (*Cicada septendecim*) which is popularly known as the seventeen-year locust. It is not a locust, but it does occupy 17 years in its development from the egg to the perfect, winged insect. Its habitat is the eastern part of North America, extending to Wisconsin on the west and to Georgia on the south. In certain years it appears in immense numbers. The female deposits 10 eggs, more or less, in a tender two-year-old twig. About two months later the tiny larvae creep forth, fall to the ground and bury themselves in the soft mold among the roots of the tree, where they remain, eating and growing, for 17 years.

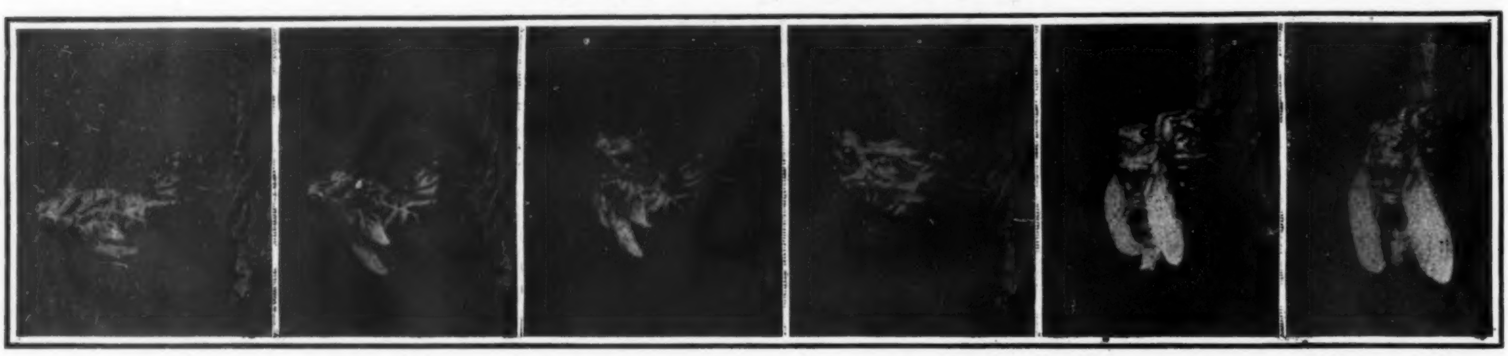
Their food consists of root sap and decaying vegetable matter. The skin is changed four times; in the second, fourth, eleventh and fifteenth years. In the seventeenth year the pupa issues from the ground, crawls up a tree and, fixing its claws firmly in the rough bark, struggles out of its skin, as a perfect cicada, in the manner illustrated in the accompanying photographs. The damage done by the cicada is not great. The twigs punctured by the females fall off, but there is ample time to replace them in seventeen years. The last appearance of the cicadas of the principal swarm, or breed, was in 1902. Hence they will not appear again until 1919.—*Illustrirte Zeitung.*



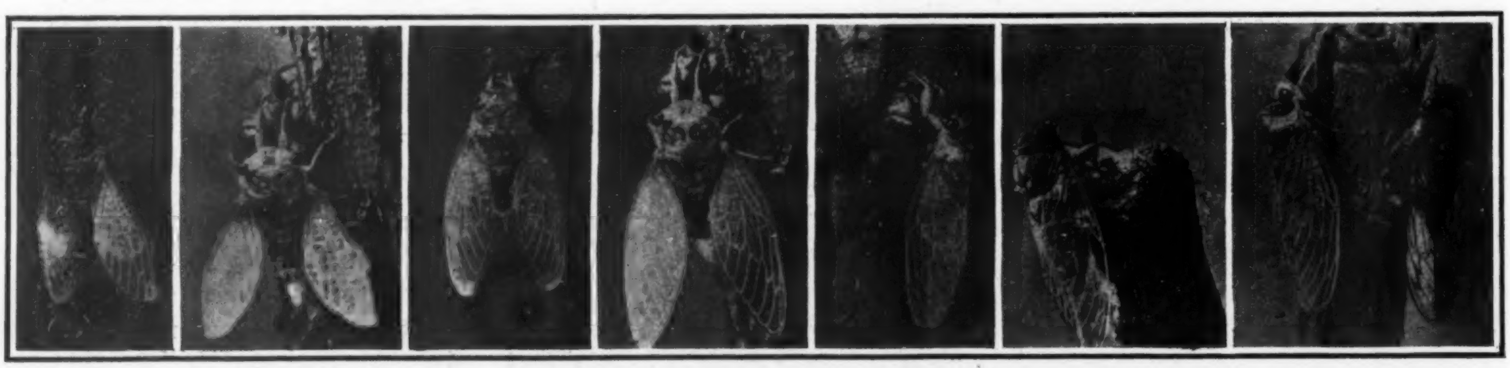
1 The pupa emerges from the ground, 2 and crawls to the nearest tree, leaving a visible track. 3 The pupa crawls up the rough bark, 4 until it finds a secure anchorage. 5 The outer skin splits at the back, 6 and the downy abdomen of the perfect insect appears.



7 The head emerges; 8 then the thorax, 9 and the empty pupa case adheres only to the bark. 10 The folded wings are slightly distended. 11 The cicada arches its back, 12 and straightens itself in its struggle for freedom.



13 The legs vibrate incessantly. 14 The body is again extended, 15 and twisted, 16 The chitinous skin of the legs hardens, 17 The empty pupa case is thrown off. 18 The wings unfold,



19 and their net-like structure becomes visible. 20 The legs move as if attempting to crawl. 21 The wings have become dry and transformation is complete. 22 Cicada seen from above. 23 Side view of cicada. 24 A male cicada which has climbed to the top of a branch and is calling for a mate. 25 The call is heard and obeyed.

THE SEVENTEEN YEAR "LOCUST" OR CICADA.

THE FIXATION OF ATMOSPHERIC NITROGEN.

THE PAULING PROCESS.

BY THE BERLIN CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

While the manufacture of nitric acid from atmospheric nitrogen according to the processes designed by Birkeland and Eyde on one hand and Frank and Caro on the other has long left the experimental stage, a rather promising process invented by the Brothers H. and G. Pauling is being introduced in Austria, where extensive works have been erected at Patsch, near Innsbruck, operated by means of water power of the River Sill.

This process is mainly based on the use of flaming arcs, which are produced between electrodes bent in a similar manner as in connection with horn-lightning arresters. These electric arms move spontaneously in space. In fact, the arc, lighted at the narrowest portion of the horn-lightning arrester, owing mainly to the upward pull of the hot gases, shows a tendency to rise, thus being interrupted with each half cycle of the alternating current, in order to be lighted anew at the narrowest and at the same time lowest portion. If now a high-speed air current be blown through the interval between the electrodes of such lightning arrester, the arc will be blown asunder even farther, thus producing arcs of considerable length. In Fig. 2 is represented such a flame as produced in the case of 1,200 kilowatts output.

As in carrying out this process into practice, flames of several hundreds of kilowatts are used, care should be taken to choose the smallest distance of electrodes to be bridged by the current of sufficient length to allow the enormous amount of air destined for combustion to be blown through without any disturbing deflection of the gas current. The electrode distance thus entailed, however, requires a comparatively high tension for the arc to be lighted, especially in the case of rapidly streaming air, which tension at the moment the arc is formed, is bound to drop considerably.

Fig. 6.—400 KILOWATTS FLAME.

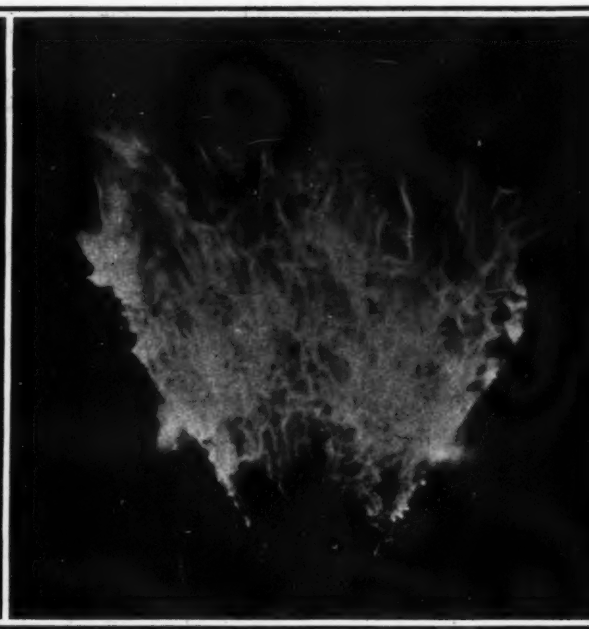


Fig. 2.—1200 KILOWATTS FLAME.

Fig. 1.—TESTING FLAME.

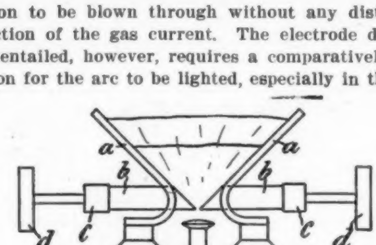


Fig. 3.—DIAGRAM OF MAIN ELECTRODES.

In order now to keep flames of considerable energy burning constantly with a relatively low tension while blowing considerable amounts of air through the interval between the electrodes, a special ignition device has been designed by the Salpetersäre Industrie Gesellschaft, which is working the Pauling process. The main electrodes *aa* (Fig. 3) at the point of shortest distance comprise a vertical slot through which can be introduced narrow knives *bb* (termed lighting knives) which are approached to a distance of some millimeters as entailed by the regular burning of the flame. This is effected by means of a hand-operated adjusting device connected by an insulating intermediary piece *cc* with the lighting knife. As these knives are very narrow they in no way interfere with the motion of the air, so that the latter can exert its full effect on entering the flame arc.

The main electrodes are so adjusted as to have an air current about 40 millimeters (1.57 inches) in width traverse the narrowest portion. This air current, which has been conveniently preheated, is introduced through a nozzle *e* which is so shaped as to cause the air current to diverge on issuing, and to surround the whole length of the electrodes. Further advantages derived from the arrangement of lighting knives are due to the stationary location of the main electrodes, and the surprisingly easy regulation of the flame. Such a flame burns with extraordinary steadiness

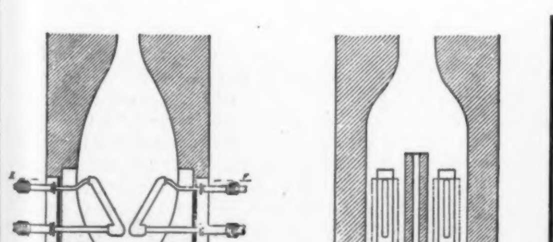


Fig. 4.—DIAGRAMS SHOWING DESIGN OF FURNACE.

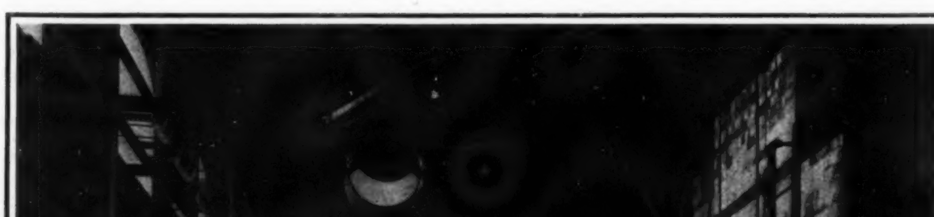


Fig. 5.—FURNACE HOUSE OF THE PAULING WORKS.

from the electrical point of view, appearing to the looker-on as a stable form, which owing to the pulverized electrode particles gives out a strikingly white light.

The efficient length of the flame is about 1 meter (3.28 feet). The electrodes are made from iron; they are cooled with water, and are able to stand an average of 200 working hours. Owing to their small thickness, the lighting knives will burn away more quickly, and accordingly have to be adjusted from time to time to a given distance.

The furnace gases are cooled by means of what is called "circulation air," which is introduced sideways into the upper portion of the flame, thus insuring a relatively rapid cooling of the gases. This circulation air is a cooled reaction mixture, branched off into the condenser previous to its entering the furnace gases. The mixture is introduced at a lower speed than the main air current, and thus exerts on the electrical arc a suction effect, causing it to be drawn out and broadened.

This cooling method allows a concentration of about 2 per cent NO to be obtained in industrial operation.

Each set of two arcs is inclosed within a masonry furnace. As in connection with all other atmospheric nitrogen processes, a tendency toward a concentration of high amount of energy in a single furnace unit can be noted.

The present type of furnace, the design of which will be inferred from Fig. 4, is run at an output of 400 kilowatts per unit under a tension of about 4,000 volts, 600 cubic meters (21,118 cubic feet) of air per hour traversing the furnace apart from the circulation gases. Twenty-four such furnaces are installed at the Innsbruck factory. Another type of furnace recently installed has an output of 1,500 to 2,000 kilowatts.

Fig. 5 represents part of the present furnace house. An industrial flame arc of 400 kilowatts is represented in Fig. 6.

These furnaces are extremely simple in operation, one man being able to take care of up to six units.

In order to allow several flame arcs to burn without inconvenience in the same circuit, the following remarkable arrangement of connections is used:

Two flames in each furnace are connected up in series, the central pole—which requires very careful insulation from the ground—being connected with one of the two outside terminals by bridges of very high resistance. A consequence of this arrangement is that the full tension at first occurs in the flame left without a bridge conductor.

As soon as this first arc has been formed the tension therein drops considerably, the whole of the latter being transferred to the terminals of the resistance, and as these at the same time are poles of the second flame arc, this will undergo about the same lighting tension as the first.

At the very moment that the arc is produced also in the second spark gap, the dynamo circuit is short-circuited by the two flames arranged in series, thus allowing a long flame arc to be formed.

This arrangement has recently been further improved. As the lighting tension is considerably higher than the working tension at which the electric arc is kept burning, the tension required for lighting the arc is generated by an auxiliary circuit of sufficient tension, but of low energy output, whereas the tension of the working circuit proper corresponds to the figure obtained in lighting the arc, that is to the working tension of the last. A convenient arrangement prevents the auxiliary circuit from being discharged into the working circuit. This arrangement of connections allows any number of furnaces to be run in parallel in a given circuit without any mutual interference. The available energy thus at any time can be fully utilized.

After leaving the furnace at a temperature of about 700 to 800 deg. C. (1,292 to 1,473 deg. F.), the gases are worked with a view to converting them into nitric acid and sodium nitrite.

The rational utilization of the heat inherent in the furnace gases constitutes one of the most important, and at the same time, difficult tasks of manufacture. This heat is applied to the following purposes: Preheating the blower air, heating the furnace draught, and vaporizing the acid and nitrite. The nitric acid is condensed in a set of stoneware tubes and towers, thus forming mainly an acid of 35 to 40 per cent. A further concentration to commercial acid of about 60 per cent is likewise effected by a systematic utilization of the heat of the furnace gases.

With the nitric acid manufacture is connected a plant for generating sodium nitrite, in which the nitrous oxides left in the air after absorption in water are integrally utilized. The output per kilowatt hour is 60 grammes (926 grains) HNO_3, while in the larger furnaces above mentioned, 85 grammes (1,312 grains) are obtained. The twenty-four furnaces installed at the beginning are intended for an aggregate output of 15,000 horse-power. Two other works of 10,000 horse-power are in course of building, one in southern France and the other in northern Italy.

THE ETHICS OF FOOD.

THE STOMACH AND PUBLIC MORALITY.

BY H. W. WILEY, PH.D.

The increasing utility of science appears to no better advantage than in its connection with public sanitation and public morals. The fundamental principle of science is truth; the fundamental guide of the scientific investigator is honesty; when truth is sought for dishonest purposes or when dishonest methods are used in seeking truth, we cannot hope for useful results. The fundamental attitude of the scientific worker is receptivity. We cannot hope that mankind will ever be free from bias and prejudice, but we can hope that a man may so rise above bias and prejudice as to be able to see things in their true light. Applied science is dynamic science; research is potential science. All truth is useful no matter how abstract it may be. Every extension of the limits of our knowledge makes in some way for the good of humanity. In this sense, all science is applied science.

The welfare of a nation is too often judged merely by the magnitude of its industries and the balance of its imports and exports. The nation that sends away more than it brings in is always becoming gradually exhausted, yet the excess of exports over imports is regarded as a mark of prosperity. It is true that a nation and science cannot advance in the midst of starvation; an abundance of food and clothing and other necessities of life are alike indispensable to material, intellectual and spiritual progress; an excess of these good things, however, is almost as injurious as a deficiency.

There is another index to national welfare which appears to me to be more certain, and that is morality. That science has an intimate relation to morality may be a new doctrine to preach, but it is not new in science. The men who have been great lights in the scientific world, have been of unimpeachable morality; they have been men who could not possibly do a wrong thing knowingly. Hence it was evident, that sooner or later, scientific investigation would come closely into touch with public morality. This particular tendency of scientific investigation, is the one which has been operative in securing the enactment of the food and drug law of the United States. It was by the investigations of scientists that attention was directed to the fraudulent representations made in regard to the characters of foods and drugs in the United States and to the sophistication to which they were subjected. A number of sciences collaborated in this work; notably among them were chemistry, pharmacy, botany and microscopy. The conditions which obtained in the United States were perhaps no different from those in other countries, hence it will be unnecessary to go into great detail.

At the time that the Food and Drug Act became law, on the last day of June, 1906, the following practices prevailed to a large extent in the United States:

1. It was quite customary to call food and drug products of an inferior character by the name of the superior article.

2. It was quite customary to sell a different article under the name of the real one.

3. It was a common custom to add various substances of the nature of a drug to foods, either to color them or to preserve them from decay.

4. It was a common practice to abstract, in whole or in part, some of the valuable ingredients of an article without changing its name.

5. It was a common custom to mix together an article of a higher value with one of a lower value, and call the mixture by the name of the article of the higher value.

6. It was a common custom to make false and misleading statements concerning the character and origin of articles, and to attach to them false and misleading designs or devices.

The general purpose of all such practices was gain. There were few forms of adulteration or misbranding, perhaps none, which were of any benefit whatever to anybody except the manufacturer and the dealer. I cannot recall a single case of sophistication of the nature mentioned, which was of an advantage to the consumer.

The magnitude of these malpractices discovered by scientific examination of food materials, was so great that public discussion was excited and public attention was drawn to them, and ultimately, a sentiment was aroused which made remedial legislation possible.

The attitude of the legislator toward questions of this kind has often been severely criticised. The criticisms may sometimes have been just; on the other hand, it is manifestly improper to impugn the motives of legislators who, year after year, pass by evils so glaring, without voting in favor of their removal. This fault is not inherent in the legislator alone. It is the common condition of the people and perhaps a desirable condition. It is not well that people should be excited unduly at all times about matters which relate to their welfare. There is a sentiment of peace, of quietude and of patience, which is becoming to a nation and is an element of strength. This condition of insensibility, as it may be called, permits a nation to pursue its ordinary course without undue divagation. It is only when great principles are at stake or intolerable evils are to be removed that the people rise in their strength and indulge in a general house-cleaning. So it was that a quarter of a century of investigation and discussion of the evils arising from the adulteration of food went on before a final effort was made to cure them by national legislation.

It is true that many of our States were led years ago to pass laws regulating sales of food and drugs. There were also national laws of a partial character, but no general act had been placed upon the statute books by Congress. All the laws relating to the sale of food and drugs were special, and referred to named articles, while in the act of June 30, 1906, a radical departure was made in passing a law which did not specialize, but applied equally to all articles used as food and drugs.

It may be said, I think with propriety, that the passage of this act was a distinct indication of the scientific progress made in the United States in applying science to sanitation and public morality. The passage of this law—in which I took an active part—and its enforcement—in which I have played a subordinate part—have called to my attention the different obstacles which had to be overcome, in the first place, in the enactment of the law, and which still remain to be overcome to secure its enforcement. The way of scientific progress will become more obvious if the obstacles which have been and are being encountered are pointed out. The first great obstacle to legislation of this kind was individual and corporate greed. People who were making money by misrepresentation and by the addition of drugs to foods, did not at all fancy a public discussion of their methods nor legal regulation of their business. This was true as regards trade in both foods and drugs. It was especially true of the very large class of Americans that make money by selling drugs to the laity, or by practising medicine *in absentia*. There are many people in our country, more perhaps than in any other, without any medical training whatever or only of the most superficial kind, that venture to practise medicine by advertising in the newspapers and magazines and by circulars distributed through the mails to the people at large. These advertisements and circulars depict in the most vivid and horrible manner, those symptoms of insidious diseases, those symptoms which perhaps are but the common slight departures from an ordinary state of health. In this way, they work upon the fears of the uninformed and easily find access to their pockets. A law which proposed in any way to restrict practices of this kind, and to require vendors of the so-called remedies to cease misrepresenting them, excited most violent and vigorous opposition from this class of our citizens. Banded together in compact organization, being also in command of abundance of money and able to patronize the press of the country by advertising liberally in the papers, they held a vantage ground from which it was difficult to dislodge them. Up to the very end, the lobby representing their interests was to be found in Washington; every means

known to them of modifying or minimizing the requirements to be made of their trade was resorted to up to the last moment.

Another interest which was found blocking the wheels of legislation, unless concessions could be granted, were the compounders of intoxicating drinks. Various forms of distilled beverages were offered to the people of the United States under false and misleading names. Liquors compounded with neutral spirits, flavors and colors were represented as "old, aged in wood" and as being particular kinds of whiskey, brandy, rum or gin. The Wholesale Liquor Dealers' Association of the United States kept a keen eye on the progress of legislation and in a circular issued a short time before the food law was passed, urged the members to contribute liberally to the funds for watching legislation, on the ground that, in previous Congresses, they had successfully prevented the passage of food and drug bills which did not meet with their approbation.

Other parties that opposed the passage of the Food and Drug Act were the manufacturers using drugs in their foods. These manufacturers were constantly appearing before committees to urge the legislation of certain forms of preservatives and colors by specific legislation or a wording of the act which would enable them to continue their practices after the bill should become a law. In fact, at the beginning of the agitation for a national law, it is probable that a large percentage of the trade engaged in the manufacture and sale of food and drug products was either opposed to any legislation whatever or extremely apathetic respecting it. As scientific inquiry proceeded, however, many manufacturers and dealers gradually abandoned the stand that they had taken, and instead of being opponents of legislation, they became its advocates. This only goes to show that the evil which was to be removed was of a nature which, when shown in its full character to the honest manufacturer, led him to join the army of those who were seeking to correct it.

Among the great organizations which were constantly in favor of legislation of this kind should be mentioned particularly, the American Medical Association. From the outset, the medical fraternity of the country has promoted legislation, both in the state and in the nation. While it is true that there are many physicians who have been either indifferent to the matter or have opposed it inactively, they are isolated in number and have no commanding influence in the councils of medical bodies. Both national and state medical associations have stood firmly for the principle of food legislation and for its proper enforcement.

The principles of interpretation which should be placed upon the law have been fully elucidated by the judges of the United States Courts. Mr. Justice McPherson of the Federal Court of the Western District of Missouri in the beginning of litigation under the Food and Drug Act, in interpreting the method of enforcing the act, said:

"Adulteration of goods and false labeling had become so common that it was well-nigh impossible to purchase pure food or that which was called for. The same was true as to medicines. Congress undertook to remedy it. One purpose was to prevent the sale of adulterations. The other purpose was to enable a purchaser to obtain what he called for and was willing to pay for. . . . This statute is to protect consumers and not producers. It is a most beneficent and righteous statute, . . . and should be enforced. It cannot be enforced if it is to be emasculated, as is sought in the present case."

Mr. Justice Humphrey, of the Southern District of Illinois, in a recent case where the United States proceeded against fifty-two cans of eggs preserved with boric acid, said:

"When there are two interpretations to be placed upon a law the court should follow that one which more clearly carries out the purpose and intent of the law. The Food and Drug Act of June 30, 1906, was intended to prevent interstate commerce in adulterated and misbranded goods. To make a ruling which the defendants ask in this case would be to evade the law. The ruling is denied and the case will proceed to trial."

On a trial of the case, the charge of the government against the eggs was sustained and the order given that they were to be destroyed as containing a "substance which may render them injurious to health."

The same attitude which the courts have thus proclaimed judicial, it seems to me, should characterize all persons who are intrusted with the enforcement of the law. I can only speak for myself in this particular, in so far as the enforcement of the law or any part of it is placed in my hands. I have acted uniformly upon the principle which has been judicially confirmed by the above decisions. Wherever there is any question concerning the meaning of the analysis or investigation which is placed before me and where it is possible to put two constructions upon that analysis, I have invariably put the one on it which protected the consumer. In other words, the person who executes the law or brings the action is neither the judge nor the jury—his duty is simply to see that the intent of the law is carried out and that all cases of apparent violation are brought before the courts. For this reason, I have always ruled that chemical antiseptics which preserve food by destroying germ life are to be excluded in the interests of public health and on that broad principle I have been willing to let the matter go to the courts. In the courts the defendants have ample opportunity to show to the contrary or the government has ample opportunity to prove its contention. The utility of science in this respect, of course, is unquestionable; it would be impossible to bring most of the cases which finally reach the courts under the Food and Drug Act without the aid of one or more of the sciences.

What, may be asked, is the attitude of scientific men in such matters? The answer is not a difficult one. The question as to whether a certain substance is injurious to health or not is often an open one and men can honestly arrange themselves on opposite sides. It is not strange, therefore, that in every instance eminent scientific authority is found favoring the use of antiseptics in foods. In such cases the court not only decides from the preponderant testimony, but also judges from the character of the testimony and the reasons for the witnesses being present in court. Unfortunately in the United States, as possibly in other countries, there are many scientific men who are, one might say, professionally engaged as scientific advisors to the defendants in suits of this kind. For instance, there are names in American scientific annals which are found frequently in cases where the Food and Drug Act is offended, especially where the defendants can afford to employ high-priced talent. I am not criticising the action of these men, but only mentioning the fact to show that the courts do not fail to take them into judicial account. This is well shown in the opinion given by Mr. Justice Humphrey of the Southern District of Illinois in considering affidavits of eminent scientific men respecting the nature of whiskey. He said:

"Complainants present sixty-nine of such affidavits and the defendants a lesser number.

"These affidavits are from rectifiers and distillers, members of the wholesale and retail liquor trade and scientists and chemists of high rank. They do not agree. Indeed, it may be said that some of them present diametrically opposite views more or less elaborately stated.

"In brief, the affidavits for complainants tend to support the proposition that a distilled spirit from grain reduced by water to potable strength from which most of the fusel oil has been removed by rectification is whiskey and that all distilled spirits from grain are 'like substances,' without reference to differences in their percentage of alcohol or of secondary products present therein.

"The affidavits presented for defendants tend to support the view that whiskey is a product made by the proper distilling of a fermented mash of grain with such care and at such a low temperature as to retain the congeneric ingredients of the grain, aged under a normal temperature for not less than four years in charred oak casks. Thus broadly in statement do the chemists disagree. They are more or less persuasive to the court according to the soundness of scientific reasoning given in support of their statements."

After a careful review of the arguments and the statements in the affidavits, Mr. Justice Humphrey ruled in favor of the defendants.

It is undoubtedly true that, before the courts in the United States at least, the testimony of the experts who appear for the State, in the capacity of protectors of the public health, carries greater weight and is considered of greater importance than the testimony of even more eminent scientific men on the other side. In fact it is difficult to see how an added substance of the kind I have mentioned is harmless. You might prove that it did not injure a certain number of individuals to whom it had been administered, but you could go no further. A positive statement respecting the injurious effects of such added bodies would overcome a vast amount of testimony as to their negative effects.

In the United States at the present time the situation in regard to the added antiseptics is as follows:

Some of them are forbidden, as for instance, boron compounds, formaldehyde and salicylic acid. One antiseptic is permitted by a special regulation, namely benzoic acid. The regulation permitting its use reads as follows:

"It having been determined that benzoate of soda mixed with food is not deleterious or poisonous and is not injurious to health, no objection will be raised under the Food and Drug Act to the use in food of benzoate of soda, provided that each container or package of such food is plainly labeled to show the presence and amount of benzoate of soda."

The question of the harmfulness of sulphites was answered in the affirmative by the investigations of the Bureau of Chemistry. Appeal from this decision has been made and the question is now before the Board of Consulting Scientific Experts.

This Board also has before it for consideration the question of the use of saccharin and of sulphate of copper. Pending the decision of the Referee Board of Consulting Scientific Experts, all these bodies are permitted to be placed in food products in the United States.

The question of alum has been considered and the recommendation has been made that it be referred also to the Board of Consulting Scientific Experts. This Board is composed of Dr. Ira Remsen, President of Johns Hopkins University; Prof. Russell H. Chittenden, Director of the Sheffield Scientific School of Yale University; C. A. Herter, Professor of Pharmacology and Therapeutics, Columbia University, New York city; J. H. Long, Professor of Chemistry, Medical College of the Northwestern University of Chicago, and Alonzo E. Taylor, Professor of Bacteriology, University of California. This Board has made investigations which have been published on the subject of benzoate of soda, reaching the conclusion that it was not injurious to health and did not lower or injuriously affect the quality of the food product to which it was added.

The summary of the condition, therefore, is this: Benzoate of soda is legalized in the United States. Sulphurous acid and sulphites, saccharin and sulphate of copper are permitted pending a report of the Referee Board. Alum is permitted for the present. Boron compounds, salicylic acid and formaldehyde are forbidden.

It appears from a study of the data of some cases of the use of antiseptics of this kind in foods, that other than strictly hygienic considerations have been potent in determining conclusions, as for instance the toleration of boron compounds in England and of copper sulphate in France. This, of course, is a most unfortunate matter; if science is to be appealed to to decide these questions, all considerations other than scientific truth and the welfare of the public should be removed from the problem. There is no doubt in my mind that science will yet, in a convincing way, answer the questions raised, and that her dictates will in the end be followed by all nations. It would not be advisable in this paper, even if space permitted, to enter into a detailed discussion of the various ways in which science is applied to great problems of public sanitation and public morality. There is no doubt that in the future answers to questions of this kind will be largely dictated by the investigations of scientific men.—Science Progress.

RADIATION PRESSURE AND REFLECTING SPHERULES.

In the monthly notices of the Royal Astronomical Society, J. W. Nicholson considers the radiation-pressure on reflecting spherules.

Since the suggestion has been revived by Arrhenius that the force of repulsion from the sun, which is necessary to a description of the phenomena associated with the tails of comets, might be caused by the pressure exerted upon the particles of the tails by the incident solar radiation, much discussion has taken place as to the possibility of a force of sufficient magnitude being exerted in this manner. The only mathematical analysis of the question, from a formal standpoint, has been given by Schwarzschild, who has found that a force of the magnitude required in the case of the tails of the most difficult type (about 18.5 times the solar gravitation) could just be obtained if the size of the particles in the tail were of the same order of dimension as the mean wave-length of the incident light, and if they were perfectly reflecting. This is, of course, the case in which the pressure is a maximum, and the fact that it would need to be attained for a very large number of the particles appears to indicate that a majority of these are of the particular dimension required, and, moreover, totally reflecting. This is a very decisive result, and it is obvious that its foundations must be strictly tested. It could be avoided if the maximum were somewhat larger, or if the rise and fall of the radiation-pressure toward and away from its maximum value were not very sharp, so that the range of size for an approximate maximum would be extensive. Both these possibilities are negatived by the numerical results which Schwarzschild gives, but these are few in number, and the whole question appears to demand further treatment. The analysis of Schwarzschild is long and complicated, and Nicholson sets out to corroborate it by a different analysis, in many respects simpler and more direct. The main conclusion of the present paper is a support of the theory in general, and the maximum is shown to be larger (22 instead of 18). Moreover, the fall of pressure from the maximum, as the size of the particles increases, is by no means so rapid as that obtained by Schwarzschild.

THE NATURE OF FATIGUE.*

THE PHYSIOLOGY AND PSYCHOLOGY OF BEING TIRED.

BY FREDERIC S. LEE, PH.D.

IN popular usage the term fatigue is employed loosely, for while it signifies, in general, a depression of physiological activity, resulting strictly from previous activity, physiological depression is often called fatigue when it is not at all clear that previous activity is at the bottom of it. It does not, however, appear to me at present necessary to hold always to the strict significance of the word, since in a given case there are still too many unknown causative factors. Moreover, in the marvelously complex weft of the human organism, where the physical and the psychical are inextricably intermingled, illusion is so readily mistaken for reality, especially in the phenomenon now before us, as often to make the detection of a genuine fatigue well nigh impossible.

Let me proceed at once to an analysis of the phenomenon of fatigue. Everyone is familiar with its sensations; but not everyone realizes that the sensations are but signs of physical and chemical conditions permeating the whole body. Fatigue is a general physiological phenomenon; not only is the whole body subject to it, but every organ, tissue and cell of which the body is composed. Like other general physiological phenomena, its study may be best approached by considering its manifestations in the parts of the organism. I propose to examine it first in the tissue of voluntary muscle, which affords certain advantages for study over other tissues, because of the ease of employing the graphic method and other physical, as well as chemical, methods.

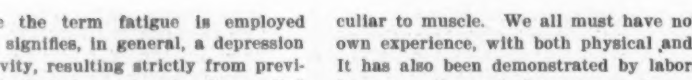


FIG. 1.

Series of contractions of a frog's sartorius muscle, excised and stimulated at intervals of two and one-half seconds. Each successive vertical line is the record of a single contraction. The contractions at first increase in extent, this stage constituting the treppe, and later decrease, this stage constituting fatigue.

If, shortly after the death of an animal, a single muscle, such as a muscle of a leg, be removed from the body, be attached to the usual muscle lever of the physiological laboratory, and be stimulated in the usual manner at regular intervals, beginning when the muscle is fresh and continuing until it is well fatigued, the graphic record of the series of resulting contractions presents a striking picture. Both the extent and the duration of the contractions may be affected. There appears early an increase in the extent of the contractions, which proceeds gradually to a maximum. This is shown in the graphic record as an increase in the height of the successive muscle curves (Fig. 1) and has been called, not inappropriately, the staircase, or *treppe*. The treppe signifies that in the early stages of muscular activity the working power of the muscle is progressively augmented—there is a temporary improvement in the power to work. This in turn means that what physiologists call the irritability of the muscle, or, in other words, its power of responding to a stimulus, has become greater; hence the same stimulus is followed by a greater contraction. A progressive improvement in the power to work in the early portion of a task, I may say, is not peculiar to muscle. We all must have noticed it in our own experience, with both physical and mental labor. It has also been demonstrated by laboratory methods in nerves, the central nervous system, and other animal and plant tissues; and it is probably a characteristic of all living substance. An analogous phenomenon is observed when living substance is put under the influence of certain drugs—a small quantity of alcohol, for example, often effects a temporary improvement in the individual's power of performing work.

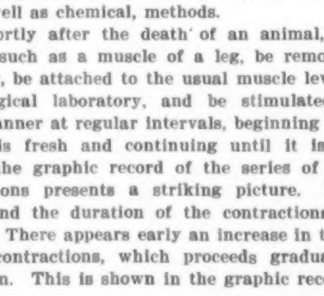


FIG. 2.

Series of contractions of the frog's gastrocnemius muscle, excised and stimulated at intervals of two seconds. Every fiftieth contraction is recorded. The increase in the duration of the process of relaxation as fatigue proceeds is shown in the progressive lengthening of the descending limb of the curves.

Following the treppe, the muscle may perform maximal contractions for a considerable time; it is in its best working conditions; its irritability is such that a given stimulus calls forth the greatest contraction of which it is capable. But sooner or later the contractions begin to diminish in extent; they sink to the level of the original amount and below it; the muscle becomes gradually weaker and weaker, until, with long-continued effort, it may finally cease altogether to lift the weight. This decrease in working power from the maximum characterizes the stage of fatigue proper. Decrease in working power may, in fact, be said to be the universal physical phenomenon of fatigue, whatever form of protoplasm we may be considering. Decrease in working power is accompanied by a decrease in irritability. The stimulus remaining the same, the work is diminished; but if the stimulus be increased in intensity, the protoplasm may again perform more work for a brief time. Sooner or later, however, all stimuli cease to be effective, and the living substance is then either exhausted or dead.

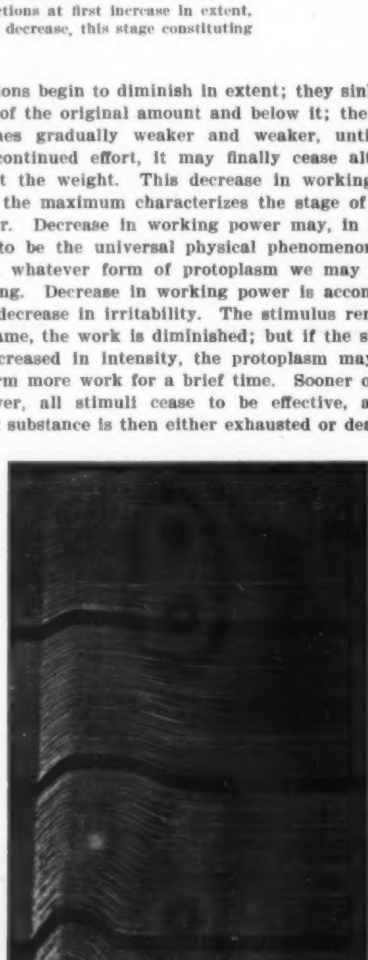


FIG. 3.

Series of 550 contractions of a frog's gastrocnemius muscle, excised and stimulated at intervals of two seconds. Every contraction is recorded, except at the places indicated by the black bands, at each of which the records of fourteen contractions are omitted. The record of the first contraction is at the bottom of the figure; that of the last one at the top. Fatigue is shown in the progressive decrease in height and the increase in length of the curves.

If, in our graphic record of muscular fatigue, we are employing a favorite subject of physiological study, the muscle of the frog, we observe another striking physical change. Early in the series, even before the treppe has reached its maximum, the duration of each contraction begins to increase, mainly by a slowing of the process of relaxation (Figs. 2 and 3). This may reach great proportions before exhaustion sets in. This slowing of relaxation appears to be wholly absent in the fatigue of warm-blooded, and presumably of human muscle (Fig. 4).

The fatigue of muscle tissue is thus characterized by marked physical peculiarities. It is only natural to ask what are the causes of these.

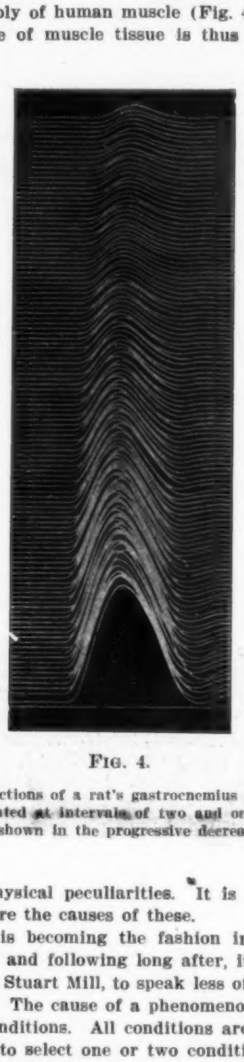


FIG. 4.

Series of contractions of a rat's gastrocnemius muscle, excised and stimulated at intervals of two and one-half seconds. Fatigue is shown in the progressive decrease in height of the curves.

Happily it is becoming the fashion in physiology, if only slowly and following long after, it is true, the usage of John Stuart Mill, to speak less of causes than of conditions. The cause of a phenomenon is the sum total of its conditions. All conditions are causes, and it is illogical to select one or two conditions and dignify them by the seemingly superior designation. In speaking of the causes of fatigue, as is often done, one usually means its chemical conditions; for within protoplasm, when in activity, there occur certain chemical or metabolic changes, with which the phenomenon of fatigue is closely associated. These chemical changes involve two general processes, namely, the consumption of certain existing substances which are essential to the activity of the protoplasm, and the production and accumulation within it of certain waste substances. Here again the muscle has yielded us our chief knowledge. Of the substances that are consumed in protoplasmic activity, we know most about two, oxygen and carbohydrate. For all aerobic tissues or organisms a continual supply of oxygen is essential to the continuance of working power—in fact, one way of bringing on the main phenomena of fatigue seems to be by eliminating oxygen. On the other hand, recent work suggests that one of the means of increasing working power or temporarily, at least, delaying its loss, is by artificially supplying oxygen to the body. It has been known for some time that with the usual conditions under which we live, the main source of the energy of muscles and probably of other organs is carbohydrate material, glycogen or its near relative sugar. In the burning of carbohydrate in the tissues its potential energy becomes the actual energy of heat and muscle work. This fact would suggest the loss of carbohydrate as one of the factors in the oncoming of fatigue, especially in its later stages. Exact laboratory investigation, moreover, shows that if most of the carbohydrate be removed from an animal's body, he presents the symptoms of pronounced fatigue; and the same is true of his individual muscles, which are incapable of performing as many contractions as the muscles of a normal animal. Feeding such an animal with sugar restores his energy and makes his muscles capable of greater labor. This latter experiment has its counterpart in the common practice by soldiers,

* An address delivered before the Section on Hygiene of the Connecticut State Teachers' Association, at New Haven and Hartford, and here reprinted from the Popular Science Monthly.

guides and explorers, of consuming sweets, such as maple sugar, chocolate and raisins, when on long marches; while for the farmer in the hayfield nothing is more gratifying than a sweetened drink. It is quite possible that future research will discover other substances, besides oxygen and carbohydrate, the loss of which to the tissues is conducive to the production of fatigue.

Oxidation and destruction of carbohydrate result in the formation of at least two waste substances, both of an acid character, namely, carbon dioxide and lactic acid. Now it is an interesting fact, derived from laboratory investigation, that both of these substances, when in any but small quantity, are inimical to protoplasmic activity, and, furthermore, that a muscle under their influence shows the very same physical symptoms that are shown by a muscle fatigued through work. A fresh muscle to which has been given a moderate or considerable quantity of either one of these substances is a muscle already fatigued, although it may have performed no work (Fig. 5). These two metabolic products are thus believed to be important factors in the causation of fatigue, and to them has been given the name, "fatigue substances." Fatigue substances are poisonous, or toxic, to protoplasm, they diminish its irritability, so that a given stimulus calls out a less response than before. Certain other substances, besides carbon dioxide and lactic acid, are thought to belong to the class of fatigue substances, some of which are probably produced normally, while others occur only in diseased conditions. Among these pathological fatigue substances may be mentioned β-oxybutyric acid, which is present often in large quantities in a body suffering from diabetes—and it is a well-known fact that a person afflicted with diabetes is incapable of any considerable labor without extreme fatigue. β-oxybutyric acid occurs also in a starving body. The weakness of a person in starvation is associated partly with the absence of the essential carbohydrate or other food stuff, and partly with the presence of β-oxybutyric acid. It is probable that future research will add still others to

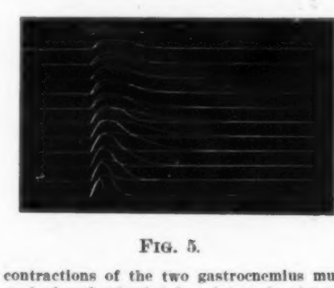


Fig. 5.

Series of contractions of the two gastrocnemius muscles of a frog, excised and stimulated at intervals of two seconds; the one muscle normal, the other under the influence of carbon dioxide. The longer, or, in the later contractions, the lower curves are those of the poisoned muscle. Every fiftieth contraction of the two muscles is recorded from the same base line. The augmenting action of the fatigue substance is visible in the first two hundred contractions; its fatiguing action in the subsequent ones.

the class of fatigue substances, especially to those which are accompaniments of disease. Fatigue is one of the most common features of disease, and especially of diseases that are characterized by an upset of the chemical balance of the body. In such cases a considerable increase in the quantity of some intermediate metabolic product may conceivably lead to fatigue phenomena.

A few years ago, in studying experimentally the action of fatigue substances on muscle, I came upon an unexpected result. Fatigue substances in small quantity have a physiological action which is exactly the reverse of that of the same substances in larger quantity—instead of depressing or fatiguing protoplasm, they act so as to augment its activity. In other words, they increase its irritability, so that a given stimulus is capable of eliciting a greater response than it could elicit without the aid of the fatigue substances. Graphic records of the contractions of muscles under the influence of very small quantities of carbon dioxide, lactic acid or other fatigue substances, show how potent this augmenting action may be (Fig. 5). I believe that in this action we have the long-sought explanation of the treppe. In the early stages of muscular work the fatigue substances are present in small quantity, in later stages in large quantity. Correspondingly in the early stages there is augmentation or treppe; in the later stages there is depression or fatigue.

Thus far I have confined myself largely to a consideration of fatigue as exhibited by muscles, where the phenomena are best known and can be studied most accurately. There is every reason to believe, however, that the main principles of muscular fatigue are demonstrable in the other tissues and organs of the body—that in them also fatigue is characterized, physically, by a diminution in working power and, chemically, by both the destruction of energy-yielding substances and the appearance of toxic metabolic products. Diminution of working power is manifested in very different ways by diverse tissues. Glands in fatigue seem to secrete less than when fresh, and it may be that the action of digestive juices is diminished. The kidneys may be deranged, so that their epithelium is unable wholly to prevent the passage of albumin from the blood to the urine. A fatigued heart is dilated, its beats are quickened and may become irregular, and its diastole, or resting period, may become abbreviated. Fatigue often results in an abnormally high bodily temperature, constituting a fatigue fever. The chemical phenomena of fatigue in the various organs and tissues, apart from the muscles, is almost wholly unstudied, and there is great need of a careful analysis of the entire subject.

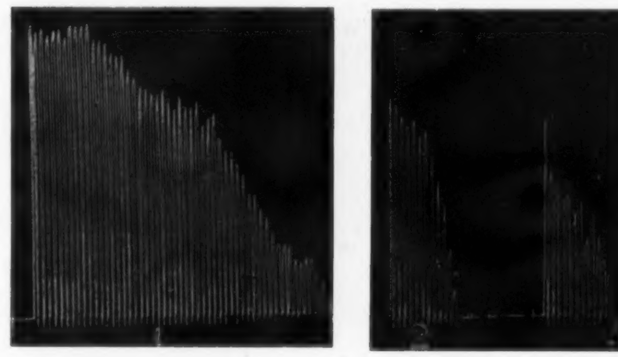


Fig. 6.

Series of contractions of the flexor muscles of a human finger. The muscle was stimulated electrically every two seconds, and the resulting contractions were therefore involuntary. Record 1 was made when the muscle was fresh; record 2 immediately after three and one-half hours had been spent in the oral examination of students; record 3 two hours after the completion of the examination. (From Mosso's "Fatigue.")

The fatigue of the nervous system is of great general interest, yet there are few subjects in experimental physiology that are more difficult of study. Notwithstanding that most of us doubtless believe that we know the symptoms of nervous fatigue well, physiologists have been able to discover only scraps of fact in this field. The isolated nerve of a cold-blooded animal, when artificially stimulated in the laboratory, can perform its work for many hours without showing the least sign of a diminution of power. Only when placed under unfavorable conditions, such as in light anesthesia, or when deprived of oxygen, does the nerve exhibit with continued stimulation a gradual loss of conductivity. From this it is inferred that the nerve fiber itself under normal circumstances is highly resistant to fatigue, and that any unfavorable dissimilative changes which it undergoes in activity are compensated for at once by an equal assimilation. This highly interesting and suggestive conclusion is perhaps equally true of nerve centers. Hodge and others, it is true, have demonstrated morphological changes in nerve cells as the result of artificial stimulation and of normal daily activity. Thus the nuclei of the brain cells of a honey bee may show a diminution in volume of 75 per cent, at the end of a day's labor; and the English sparrow, though popularly regarded as less typical of industry, reveals almost as much cerebral activity. Notwithstanding these evidences of metabolism, no one has yet succeeded in obtaining, by direct or reflex artificial stimulation of the nerve ganglia, the spinal cord or the brain of animals, indisputable physiological evidence of the genuine fatigue of the nerve structures involved. Many attempts have been made to detect fatigue in the nervous system by testing the muscular power, as by the employment of the ergograph, the instrument in which a muscle or set of muscles is made to perform a series of voluntary contractions and lift a given weight, the progress of fatigue being indicated by the rate at which the lift diminishes. But endeavors to arrive at an exact analysis of the result of such an apparently simple experiment have given rise to a controversy as to the location of the fatigue, some investigators claiming it for the muscles, others for the brain.

A still further attempt at the investigation of brain fatigue is through the study of certain mental processes during or following long-continued effort. Mental fatigue is characterized by a diminution of attention, a difficulty in concentrating one's thoughts, slowness in reacting to sensory stimuli, in memorizing or in reasoning, difficulty in recalling memorized passages, errors or slowness in mathematical calculations, and other phenomena. While these are obvious in the fatigued individual, all attempts at exact measurement of them and the deduction therefrom of the degree of psychical or physical fatigue have failed.

Thus, while some of the characteristics of nervous fatigue are known, all methods, heretofore adopted to study the fatigue of the central nervous system exactly with a view of determining its relative susceptibility to fatigue are unsatisfactory. The preponderance of evidence at present seems to me to be in favor of a high degree of resistance to fatigue on the part of the brain and spinal cord, as of the nerve fiber itself. In fact, such a condition is what we should expect *a priori*. The nervous system is the administrative instrument of the individual; it directs, controls and harmonizes the work of the parts of the organic machine, and gives unity to the whole. It is not the frail, delicate thing, easily put out of gear, that we at times believe it to be. It is capable of enormous demands on its powers and of enormous resistance. It is the last system to succumb in many diseases and in such a dire condition as starvation. It would seem to be only highly advantageous to the organism that its nervous system should be able to resist the oncoming of fatigue, with all the direful consequences that might follow its advent.

After thus analyzing the phenomena of fatigue in their manifestations in the various organs and tissues of a complex body, let us briefly consider fatigue as we feel it in ourselves. When we perform a long-continued and ultimately fatiguing task, either physical or mental, we can recognize, with little difficulty, three successive stages of working power, although these are not sharply separated from one another. During the first stage our working power gradually increases; during the second it remains approximately stationary at a high level; during the third it gradually decreases. During the first stage our performance is at first distinctly up-hill work; we find it difficult to concentrate our attention; we feel already fatigued; we could easily give up and do no more. But, surprisingly enough, if we keep on we find the work getting easier; we can accomplish more and more, seemingly without greater effort; we seem to be breaking

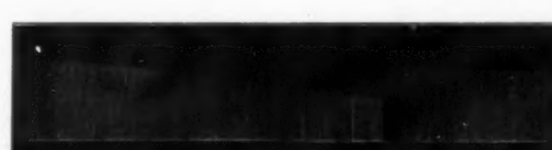


Fig. 7.

Series of contractions of a frog's gastrocnemius muscle *in situ* and stimulated at intervals of two seconds. The flow of blood through the muscle was stopped by ligating the artery, and the record of fatigue was made. At the break in the series, the muscle rested five minutes, during which time the ligature was removed and the blood was allowed to circulate through the muscle. The record of contractions at the right of the break was made immediately after the resting period, and while the blood was still circulating.

through barriers that have hindered us; our sensations are agreeable; we say that we are getting our second wind; we feel new courage and no longer care to give up. Before we realize it we have gotten our second wind and have passed into the second stage; our working power is at its best, and we continue to labor, heedless of time; if we attempt to philosophize, we are only conscious of the fact that our labor is easy and our burden light. But this stage, though it may be long continued, ultimately gives place to the third stage, when we realize that our powers, after all, are limited, that work is hard, that either we must put forth greater efforts or our output diminishes, and that we are really tired. Now these three stages of individual labor are but the three stages which we have already seen epitomized in the isolated muscle—the treppe, the period of maximum contractions, and the fatigue—and I do not doubt that they are associated with the same chemical phenomena. The stage of getting our second wind is when our fatigue substances are in minute quantity, and they gradually augment our physiological irritability and our output of energy. The stage of our best work is when irritability is at its highest, we have a store of oxidizable fuel, and toxic products have not yet begun to exert their deleterious action. The stage of fatigue is when our fuel is becoming exhausted, its waste products are clogging the furnaces, and physiological irritability is low.

Fatigue, as we feel it after excessive work, is often spoken of as a sensation. Really it is a great complex of sensations. These sensations differ in some degree according to the character of the work, whether it is mental or physical, and if physical, according to the particular groups of muscles employed. But in extreme fatigue such differences are comparatively slight. They may be a "tired" feeling in the head of obscure origin; pain and soreness in the muscles, resulting from an excessive accumulation of blood or lymph, or perhaps from an actual rupture of muscle fibers; stiffness in the joints, resulting from lymph accumulation; swelling of hands and feet, from the same cause; sleepiness, which is accompanied by cerebral anemia; even a feverish temperature because of derangement of the temperature-regulating mechanism; and many other sensations, but, most general of all, a disinclination to perform either mental or physical labor, which may be due in part to general depression of the nervous system, in part to the presence of the unusual sensations, and in part to the mental recognition of the fact that the irritability of our issues has become diminished and a greater stimulus than before is now required to induce a given action. It is not often possible for the individual to make a satisfactory analysis of the excessively complicated compound of sensations, which he may possess when his body is in a fatigued state. But it has come now to be generally accepted that the sensations of fatigue result largely from events happening outside of the brain and spinal cord, events of which I have been speaking under the head of physical and chemical phenomena. Such events are not, however, confined to the particular tissues that have performed the fatiguing work, for fatigue substances, though produced in one tissue and fatiguing it, may be carried by the blood to others and there also exert their characteristic action. This fact, that the excessive work of one tissue may cause the fatigue of other tissues, is of great practical importance to us in our daily life. We all believe that excessive muscular work may cause mental weariness. It has been shown by laboratory experimentation that the reverse is true, that excessive mental work may cause muscular weariness. In an experiment upon himself, Dr. Maggiora, of Turin, found that the flexor muscles of his middle finger, upon being stimulated by an electric current applied directly to them, were capable of lifting a certain weight fifty-three times before temporary exhaustion set in (Fig. 6). Soon after the completion of the test he entered the class room and devoted the subsequent three and one-half hours to the oral examination of students, a task which, he being then a teacher of little experience, was excessively difficult. Immediately after the end of the examination he tested his lifting power again and found his muscles capable of making only twelve contractions. It is often thought that the best means of recuperating after a day's hard mental labor is through the performance of physical exercise. A temporary change of occupation may, indeed, be of great benefit, by relieving an exhausted organ and an exhausted focus of attention. But physiology tells that a tired brain means a tired body, and that with the brain fagged there is nothing culpable in a desire for not only mental but physical rest.

But there is another aspect of personal fatigue which we cannot neglect. Our sensations become our servants or our masters, according as we will. Either we control them, or they control us. Is it legitimate, is it moral, to yield to every sign of weariness? Here we meet at once the problem of the formation of habits. Fatigue may easily become with us a habit, a habit which is destructive to legitimate effort. We have all known the perpetually tired man, the chronically fatigued, to whom both initiative and performance alike are distasteful and to be avoided, when possible. This condition may at times be so pronounced as to be positively pathological, demanding special curative treatment. Fortunately such a condition is rare. Most of us may live on a high or a low plane of activity at will; we may do much or little; we may yield early to fatigue or we may successfully resist it for a time with impunity.

The more one studies physiology the more one appreciates the fact that protoplasm possesses an enormous power of work, and that the human body is endowed with marvelous capacity. Whether we shall get our second wind, or, having gotten it, whether we shall utilize to the full our powers of work, is a matter of our own will. I believe that few of us live up to our opportunities for accomplishing things. We are too inclined to yield to the early demands of fatigue. Even without exceptional hereditary endowment more of us might have, if we would, the endurance of a Weston, the discernment of a Darwin, the shrewdness of a Harriman, the determination of a Peary, or the insatiate desire to be on top which distinguished our late president. In his very sensible and characteristically delightful essay on "The Energies of Men," William James says:

"The human individual lives usually far within his limits; he possesses powers of various sorts which he habitually fails to use. He energizes below his *maximum*, and he behaves below his *optimum*. In elementary faculty, in co-ordination, in power of *inhibition* and control, in every conceivable way, his life is contracted like the field of vision of an hysteric subject—but with less excuse, for the poor hysteric is diseased, while in the rest of us it is only an inveterate *habit*—the habit of inferiority to our full self—that is bad. . . . We live subject to arrest by degrees of fatigue which we have come only from habit to obey. Most of us may learn to push the barriers farther off, and to live in perfect comfort on much higher levels of power."

Herein lies the value of training. Training, whether of the child or the adult, the athlete or the thinker, consists largely in the development of a power of resistance to the toxic fatigue substances, and is not unlike the production of a condition of tolerance to a poisonous drug by the administration of successively increasing doses of it. Physical training is not fundamentally different from general educational training. Habits of industry, which every educational system strives to develop in the child, are the converse of habits of fatigue, and in the last analysis habits of industry mean, in very large part, an acquired power of resistance to fatigue substances.

One difficulty which we all recognize is that of distinguishing between real and pseudo-fatigue in ourselves or others, and knowing when a rational degree of real fatigue has been reached. The matter is a vital one to teachers, for a knowledge of the rate at which working power diminishes, of the presence or absence of a fatigue state at a given moment, might be of material help in directing the pupil's work. Various studies have been made of the fatigue of school children, but the results of all of them are unsatisfactory because of the lack of a satisfactory method of investigation. Even the physiologist in his laboratory, however exact he may be with the muscles of animals, has no method of measuring accurately the degree of fatigue in the intact body of a human being. Our sensations are not altogether a safe guide. We often interpret a temporary sleepiness, a temporary lack of power of attention, and uneasiness to be free from our task, as signs of real weariness and evidence that we should stop our labors. Yet we know that often a slight change of conditions will seem to give us renewed energy, the feeling of fatigue is gone and we turn with freshness to our task; our supposed fatigue was only an illusion. Even with our imperfect experimental methods, however, enough has been discovered to show, among other things, that human beings differ greatly in the rate at which fatigue develops. Mosso demonstrated this many years ago, though his methods are not now regarded as the best.

I have thus far confined myself to a consideration of the nature of fatigue and the conditions under which it develops. Recovery from fatigue is perhaps of even greater interest. Both in the isolated muscle and in the intact organism, fatigue may be carried so far that recovery is difficult or even impossible. The later stages of fatigue are often spoken of as exhaustion, but obviously no sharp line can be drawn between fatigue and exhaustion. Exhaustion is probably most common when labor is continued for years without adequate resting periods. Exhaustion from a temporary effort is of rare occurrence, observable occasionally in athletes and in persons upon whom there is made a sudden and unexpected demand for enormous physical or mental exertion. Usually, however, when a fatiguing expenditure of energy by a living tissue ceases, recovery begins at once. Even in the excised muscle, with all supply of blood cut off, a few minutes' rest allows for a certain degree of recuperation, due possibly to the absorption of oxygen. If a weak solution of common salt, or, better, a suitable mixture of various salts, be passed through the blood vessels of the muscle for a few minutes and thus the accumulated fatigue substances be, at least partially, washed out, the recuperation is greater. If a small quantity of glucose be added to the solution, or if nutritive oxygenated blood be introduced, there is still greater recovery, and the power of further work is much enhanced (Fig. 7). All of these methods are physiological—in them the chemical conditions conducing to fatigue are replaced by reverse conditions and the result is reversed—oxygen and food are introduced, carbon dioxide and lactic acid are removed, and there is a restoration of working power. In the living human body the same processes and the same result are best brought about through the combined agencies of food and rest, with sleep. Sleep is here of value since, by its complete inhibition of the more obvious corporeal activities, it makes rest more complete and thus allows the more complete elimination of fatigue substances and restoration of those things that are essential to future activity.

Equally difficult with the problem of the extent to which labor may safely be carried is the problem of how much food, rest and sleep are required for healthful recuperation. How much we think we require is another question, for here again our sensations are misleading and it is easy to acquire habits which bear little relation to nature's demands. We here assembled, being in the shadow of Prof. Chittenden's laboratory, are in the very center of the low-protein camp, and with appetites bridled we can safely defy those who tell us to eat what we please, when we please, and all that we please. There is, indeed, little doubt of the correctness of the main contention of Chittenden, Fletcher, Fisher and their followers, that it is physiologically advantageous to consume less protein than most of the civilized races consume, and it is impossible to avoid a strong suspicion that the presence of a superfluity of food stuffs within the body leads to an accumulation of intermediate metabolic products which in themselves act on the tissues as fatigue substances. The physiological optimum in the matter of quantity of food probably differs with each individual and, with our customarily unscientific habits of judging ourselves, is probably rarely known. This is equally true of the amount of rest and sleep required for recuperation. Our fathers told us "eight hours' work, eight hours' rest and eight hours' sleep"—yet did our fathers, more than we, literally observe the adage? As I believe that most of us eat too much, so I believe that most of us work too briefly and rest too long. Yet more significant than duration is intensity. "Work when we work, and play when we play," is not a meaningless nursery jingle, but a wise physiological dictum. Application, concentration, putting our whole selves into our task, with a wholesome disregard of fancied fatigue—that is the method of accomplishment. But when fatigue really comes, then should the task be laid completely aside for restoration. Play is one of the surest agencies for mental relaxation in the waking state. Pathetic was the confession of one of the world's most busy workers a few years before his death, at the age of forty-five, that he had "almost forgotten how to play." Effective sleep should be dreamless, and if it is of the right sort, it need not occupy one third of all our life. For most persons eight hours of actual sleep would mean nine hours in bed—and only a sluggard would demand that.

Food, rest, play and sleep may be regarded as the effective physiological antidotes to fatigue. One ingenious German investigator would add to these another. In an experimental study he believes that he has demonstrated in fatigued animals the existence of a fatigue toxin, different from simple carbon dioxide and lactic acid and allied to the toxins produced by bacteria. He claim to have extracted this in a pure form, and upon successive injections of it for a period of time into the bodies of other animals their tissues have produced, he claims, an antidote to it in the form of a real antitoxin. This antitoxin of fatigue, if administered to fatigued animals or even human beings, is said to bring about prompt recovery; if administered to fresh organisms it is said to greatly prolong their working period. I am not prepared to deny the truth of these claims, but such striking discoveries should be confirmed by other investigators before one can fully believe in their reality. It may be said that present science knows no safe, quickly acting, effective antidote to the toxic action of fatigue substances. There can be no doubt, however, about the temporary anti-fatiguing power of certain drugs. The caffeine of coffee and tea is one of these, and the theobromine of cocoa is another. Alcohol, too, may act as a temporary whip. When administered to even an isolated muscle, in small quantity, it augments activity, quickens

contraction and delays fatigue; in large quantity it is depressing and hastens fatigue. In these respects alcohol is not unlike the physiological fatigue substances. It is undoubtedly useful in very brief emergencies involving fatiguing effort, but like other drugs, its usefulness lies outside normal physiological life.

Besides the more purely physiological and psychological aspects of fatigue, it has an important relation to many sociological problems. In its milder form it may be regarded as a blessing, since it leads to healthy rest. But if its warnings are not heeded, it may prove a serious affliction. By reason of its inhibition of activity it is a potent sociological force. It is one of the causes of misery and poverty and disease; it is an inciter of crime; it has helped to lose battles; it has limited industrial expansion. Prof. Irving Fisher has recently estimated the minimum annual cost of serious illness in this country as one and a half billion dollars, and says: "The economic waste from undue fatigue is probably much greater than the waste from serious illness." Fatigue must be reckoned with in all human activities, and its toll must be rigidly paid. Happy is he who has the power so to direct his bodily machine as to obtain from it its highest efficiency.

THE ISOLATION OF AN ION.—I.*

A PRECISION MEASUREMENT OF ITS CHARGE AND THE CORRECTION OF STOKES'S LAW.

BY PROF. R. A. MILLIKEN, UNIVERSITY OF CHICAGO.

1. INTRODUCTION.

There is presented herewith a new method of studying gaseous ionization, with the aid of which it has been found possible:

1. To catch upon a minute droplet of oil and to hold under observation for an indefinite length of time one single atmospheric ion or any desired number of such ions between 1 and 150.

2. To present direct and tangible demonstration, through the study of the behavior in electrical and gravitational fields of this oil drop carrying its captured ions, of the correctness of the view advanced many years ago and supported by evidence from many sources that all electrical charges, however produced, are exact multiples of one definite, elementary, electrical charge; in other words, that an electrical charge, instead of being spread uniformly over a charged surface, has a definite granular structure, consisting, in fact, of an exact number of specks, or atoms of electricity, all precisely alike, peppered over the surface of the charged body.

3. To make an exact determination of the value of this elementary electrical charge, which is free from all questionable theoretical assumptions and is limited in accuracy only by the accuracy which is attainable in the measurement of the coefficient of viscosity of air.

4. To observe directly the order of magnitude of the kinetic energy of agitation of a molecule, and thus to bring forward new, direct, and most convincing evidence of the correctness of the kinetic theory of matter.

5. To demonstrate that the great majority of the ions of the air of both positive and negative sign carry the elementary electrical charge, and to present convincing evidence that some atmospheric ions carry exact multiples of this charge, in other words, that the phenomena of valency are exhibited to some extent in gaseous ionization.

6. To show that the law of motion of a small sphere through a resisting medium, commonly known as Stokes's law, breaks down as the diameter of the sphere becomes comparable with the mean free path of the molecules of the medium, and to determine the exact way in which it breaks down.

The investigation by means of which these results have been obtained differs from most of the equally important ones which are carried on in the physical laboratory, in that the method used is so simple, and the conclusions follow so inevitably from the experimental data, that even the man on the streets can scarcely fail to understand the method or to appreciate the results.

2. THE METHOD.

The method by which these results have been obtained and by which still further important results bid fair to be obtained grew out of some experiments which were presented in a preceding paper.[1] It is in brief as follows: A cloud of fine droplets of oil, or of mercury, or of some other non-volatile substance is blown by means of an atomizer[2] over a horizontal air condenser and a few of the droplets in this cloud are allowed to fall through a pinhole in the middle of the upper plate of this condenser into the space between the plates. The pinhole is then closed for the sake of shutting out air currents. The condenser used consists in most of the experiments of two heavy, circular, and accurately planed brass plates, 20 centimeters in diameter, held exactly 16 millimeters apart by means of three small ebonite posts. The plates are inclosed, and the temperature controlled so that the air within the condenser is altogether stagnant. The droplet, once inside the condenser, is illuminated through a small window by a beam from an arc light, so that it appears in the field of view of the observing cathetometer telescope like a bright star on a black background. This star, of course, falls under the action of gravity toward the lower plate, but before it reaches it, an electrical field of strength between 3,000 volts and 8,000 volts per centimeter is thrown on between the plates, and, if the droplet had received a charge of the proper sign and strength as it was blown out through the atomizer, it is pulled up by this field against gravity, toward the upper plate. Before it strikes this plate the field is thrown off, the plates short-circuited, and the time required by the drop to fall under gravity the distance corresponding to the space between the cross hairs of the observing telescope is accurately determined. Then the rate at which the droplet moves up under the influence of the field is measured by timing it through the same distance, when the field is on. This operation is repeated and the speeds checked an indefinite number of times, or until the droplet catches an ion from among those which exist normally in air, or which have been produced in the space between the plates by any of the usual ionizing agents like radium or X-rays. The fact that an ion has been caught, and the exact instant at which the event happened, is signaled to the observer by the change in the speed of the droplet under the influence of the field. From the sign and magnitude of this change in speed, taken in connection with the constant speed under gravity, the sign and the exact value of the charge carried by the captured ion are determined. The error in a single observation need not exceed one-third of one per cent. Furthermore, it is from the values of the speeds observed that all of the conclusions above mentioned are directly and simply deduced.

3. THE DEDUCTION OF THE RELATIVE VALUES OF THE CHARGES CARRIED BY A GIVEN DROPLET.

The relations between the mass m of a drop, the charge e_n which it carries, its speed v_1 under gravity, and its speed v_2 under the influence of an electrical field of strength F, are given by the simple equation

$$\frac{v_1}{v_2} = \frac{mg}{Fe_n - mg} \text{ or } e_n = \frac{mg}{F}(v_1 + v_2) \text{ ....(1)}$$

This equation involves no assumption whatever, save that the speed of the drop is proportional to the force acting upon it, an assumption which is fully and accurately tested experimentally in the following work. Furthermore, equation (1) is sufficient not only for the correct determination of the relative values of all of the charges which a given drop may have after the capture of a larger or smaller number of ions, but it is also sufficient for the establishment of all of the assertions made above, except 3, 4 and 6, and for the establishment of 4, no other exact relationship is needed. However, for the sake of obtaining a provisional estimate of the value of m in equation (1), and therefore of making a provisional determination of the absolute values of the charges carried by the drop, Stokes's law will, for the present, be assumed to be correct, but it is to be distinctly borne in mind, that the conclusions just now under consideration are not at all dependent upon the validity of this assumption.

This law states that if μ is the coefficient of viscosity of a medium, x the force acting upon a spherical drop of radius a in that medium, and v the velocity with which the drop moves under the influence of the force, then

$$x = 6\pi\mu av \text{ ....(2)}$$

The substitution in this equation of the resulting gravitational force acting on a spherical drop of density σ in a medium or density ρ gives the usual expression for the rate of fall, according to Stokes, of a drop under gravity, viz.,

$$v_1 = \frac{2}{9}\frac{ga^2}{\mu}(\sigma - \rho) \text{..... ... .(3)}$$

The elimination of m from (1) by means of (3), and the further relation $m = \frac{4}{3}\pi a^3\sigma$ gives the charge e_n in the form

$$e_n = \frac{4}{3}\pi\left(\frac{9\mu}{2g(\sigma - \rho)}\right)^{\frac{3}{2}}\frac{\sigma g}{F}(v_1 + v_2)v_1^{\frac{1}{2}} \text{ ...(4)}$$

It is from this equation that the values of e_n in Tables I.-XI. are obtained.

4. PRELIMINARY OBSERVATIONS UPON THE CATCHING OF IONS BY OIL DROPS.

Table I. presents the record of the observations taken upon a drop which was watched through a period of four and one-half hours as it was alternately moved up and down between the cross-hairs of the observing telescope under the influence of the field F and gravity G. How completely the errors arising from evaporation, convection currents, or any sort of disturbances in the air, are eliminated, is shown by the constancy during all this time in the value of the velocity under gravity. This constancy was not attained without a considerable amount of experimenting which will be described in full elsewhere. It is sufficient here to state that the heating effects of the illuminating arc were eliminated, first by filtering the light through about two feet of water, and second, by shutting off the light from the arc altogether except at occasional instants, when the shutter was opened to see that the star was in place, or to make an observation of the instant of its transit across a cross-hair. Further evidence of the complete stagnancy of the air is furnished by the fact that for an hour or more at a time the drop would not drift more than two or three millimeters to one side or the other of the point at which it entered the field.

The observations in Table I. are far less accurate than many of those which follow, the timing being done in the case of Table I. with a stop-watch, while many of the later timings were taken with a chronograph. Nevertheless this series is presented because of the unusual length of time over which the drop was observed, and because of the rather unusual variety of phenomena which it presents.

The column headed G shows the successive times, in seconds, taken by the droplet to fall under gravity the distance between the cross-hairs. It will be seen that in the course of the four and one-half hours the value of the time increases very slightly, thereby showing that the drop is very slowly evaporating. Furthermore, there are rather marked fluctuations recorded in the first ten observations which are probably due to the fact that in this part of the observation the shutter was open so much as to produce very slight convection currents.

The column headed F is the time of ascent of the drop between the cross-hairs under the action of the field. The column headed e_n is the value of the charge carried by the drop as computed from equation (4). The column headed n gives the number by which the values of the preceding column must be divided to obtain the numbers in the last column. The numbers in the e_n column are in general averages of all the observations of the table which are designated by the same numeral in the n column. If a given observation is not included in the average in the e_n column, a blank appears opposite that observation in the last two columns. On account of the slow change in the value of G, the observations are arranged in groups and the average value of G for each group is placed opposite that group in the first column. The reading of the PD between the plates, taken at the mean time corresponding to each group, is labeled V

* Paper read before the American Physical Society.

[1] Phil. Mag., 19, p. 209, 1910.

[2] The atomizer method of producing very minute but accurately spherical drops for the purpose of studying their behavior in fluid media, was first conceived and successfully carried out in 1908 at the Ryerson Laboratory, by Mr. J. Y. Lee, while he was engaged in a quantitative investigation of Brownian movements. His spheres were blown from Wood's metal, wax, and other like substances which solidify at ordinary temperatures. Since then the method has been almost continuously in use here upon this and a number of other problems, and elsewhere upon similar problems.

and placed just below or just above the mean G corresponding to that group. The PD was applied by means of a storage battery.

(To be continued.)

TABLE I.

Negative Drop.

Distance between cross hairs .... = 1.010 centimeters.
Distance between plates .... = 1.600 centimeters.
Temperature .... = 24.6° Centigrade.
Density of oil at 25° Centigrade .... = 0.896
Viscosity of air at 25.2° Centigrade ... = 0.0001837

	G Sec.	F Sec.	n	$e_n \times 10^{10}$	$e_1 \times 10^{10}$
	22.8 22.0	29.0 21.8	7 8	34.47 39.45	4.923 4.931
G = 22.38 .... V = 7950	22.3 22.4 22.0 22.0	17.2 .... 17.3 17.3	9	44.42	4.936
	22.0 22.7	14.2 21.5	10 8	49.41 39.45	4.941 .....
	22.9 22.4 22.8	11.0 17.4 14.3	12 9 10	59.12 44.42 49.41	4.927 ....
V = 7920 .... G = 22.80	22.8 22.8	12.2 12.3	11	53.92	4.902
F = 14.17	23.0 22.8 .... 22.8	.... 14.2 .... 14.0	10	49.41	4.941
F = 17.13	22.8 .... 22.9	17.0 17.2 17.2	9	44.42	4.936
F = 10.73	22.8 22.8 22.8	10.9 10.9 10.6	12	59.12	4.927
V = 7900 .... G = 22.82	22.8 22.8	12.2 8.7	11 14	53.92 68.65	4.902 4.904
F = 6.7	22.7 22.9	6.8 6.6	17	83.22	4.894
F = 7.25	22.8 .... 23.0	7.2 7.2 7.3 7.3 7.2 7.4 7.3 7.2	16	78.34	4.897
F = 8.65	22.8 23.1	8.6 8.7	14	68.65	4.904
	23.2	9.8 9.8	13	63.68	4.900
F = 10.63	23.5 23.4	10.7 10.6	12	59.12	4.927
V = 7820 .... G = 23.14 .... F = 9.57	23.2 23.0 23.0 23.2 23.0 .... 22.9 .... 22.9	9.6 9.6 9.6 9.5 9.6 9.4 9.2 9.6 9.6 9.6	13	63.68	4.900
	....	10.6	12	59.12	4.927
F = 8.65	.... 23.4	8.7 8.6	14	68.65	4.904
F = 12.25	23.0 23.3 .... 23.2	12.3 12.2 12.1 12.4	11	53.92	4.902
	Change forced with radium.				
F = 72.10	23.4 22.9 23.2 23.5 23.0	72.4 72.4 72.2 71.8 71.7	5	24.60	4.920
V = 7800	23.0 23.2	39.2 39.2	6	.....	.....
G = 23.22	....	27.4 20.7	7 8	34.47 39.38	..... 4.922
	....	26.9 27.2	7	34.47	4.923
F = 39.20	23.3 23.3 23.4 23.3	39.5 39.2 39.0 39.1	6	29.62	4.937
	23.2	71.8	5	24.60	4.920
	23.4 23.2	382.5 374.0	4	.....	.....
	23.4 23.8	71.0 70.6	5	24.60	4.920
V = 7760 .... G = 23.43	23.4 23.1	38.5 39.2	6	.....	.....
	23.5 23.4 23.6 23.4 23.6 23.4	70.3 70.5 71.2 71.4 71.0 71.4	5	24.60	4.920
F = 379.6	23.5 23.4 23.2 23.4 23.6 23.3 23.4	380.6 384.6 380.0 375.4 380.4 374.0 383.6	4	19.66	4.915
F = 39.18 .... V = 77.30 .... G = 23.46	.... 23.5 23.5 23.4	39.2 39.2 39.0 39.6	6	29.62	4.937
F = 70.65	....	70.8 70.4 70.6	5	24.60	4.920
	23.6	378.0	4	19.66	4.915
	Saw it here, at end of 305 seconds, pick up two negatives.				
	23.6 23.6	39.4 70.8	6 5	29.62 24.60	4.937 4.920

Mean of all $e_1 5$ = **4.917**

Differences:
24.00 — 19.66 .... = 4.94
29.62 — 24.60 .... = 5.02
34.47 — 29.52 .... = 4.85
39.38 — 34.47 .... = 4.91

Mean difference .... = 4.93

SCIENCE NOTES.

H. E. Ives, in the Physical Review, considers the photographic evidence for dispersion of light in space. It was found by Tikhoff that when photographed through colored glasses faint stars were more distinct on the negatives taken with light of longer wavelength, and he urged from this that there was a scattering or dispersion of light in space. Now it is pointed out that the scale of gradation of a photographic plate may be very different for lights of different wavelengths. It is known that a "red" image develops up slower than a "blue" image, although both may finally attain the same density, and, further, the sensitive layer obtained by bathing plates in dyes is very thin. Laboratory tests of exposures through red and blue screens were made, and exhibited many of the phenomena shown by the star photographs, so that the dispersion of light in space cannot yet be regarded as satisfactorily demonstrated.

How big are the particles of comets' tails and what is their light-scattering effect? Various opinions have been held on the subject, which are considered by J. W. Nicholson in the Philosophical Magazine. That the majority of the particles are not of molecular size, in spite of the probable tenuity of the gases in the tail, now seems to be fairly certain. The theory of radiation-pressure proposed in general terms by Arrhenius, and examined later by Schwarzchild from a strictly mathematical standpoint, demands, if it is to give a description of the phenomena associated with the tails of the most difficult type, the existence of particles of such a size that the pressure of solar radiation on a single particle must be about nineteen times as great as the solar gravitation. Nicholson, by different analysis, has substantially confirmed the results of Schwarzschild. It thus appears that on a radiation-pressure theory of the tails, particles must be present whose dimensions are comparable with the wave-length of light, and these must consist of aggregates of a very large number of molecules. In view of the low pressure at any point of the tail, a necessity appears to arise for the presence of a large number of particles of much greater size, which, by continuous disintegration, give rise to a sufficient number of the dimensions proper for a maximum radiation pressure.

A gum which gives a highly adhesive mass with cold water is described in a French patent taken out by J. Kantorowicz. Starch or starchy materials, such as potatoes or flour, is intimately mixed with water and heated in such a way—for example, by passage in a thin layer over steam-heated rollers—as to convert the starch first into paste, and then into a desiccated mass which can be removed from the roller in the form of flakes and, if necessary, ground. In order to effect this, the rollers, or other heating surface, must be maintained at a temperature of 110 deg. C. A chemical reagent such as an alkali or an acid is added either before the heating process, or subsequently, in order to increase the adhesive power of the mass. For example, 100 kilogrammes of finely ground potatoes are mixed with 0.5 kilogramme of hydrochloric acid (specific gravity 1.2) and 300 liters of water. The mixture is converted by passing it over rollers heated to 110 deg. C., first into a paste and then into a desiccated mass, which is removed from the rollers and ground. Instead of heating this mixture at once to 110 deg. C., it may first be converted into paste at 75 deg. C., and then desiccated at 110 deg. C. As a second example of the process, 100 kilogrammes of flour are mixed with 500 liters of water, and the mixture is heated in a thin layer on rollers heated by steam to 120 deg. C. The flaky mass obtained is coarsely powdered and mixed with 2 kilogrammes of powdered sodium carbonate. The amount of sodium carbonate required is determined by trial and is dependent upon the degree of adhesiveness desired.

ENGINEERING NOTES.

The designers of the "Von der Tann" have undoubtedly introduced into her some very striking features. Among these may be remarked the system of air ducts to the stokeholds which, in place of cowls or hooded ventilators, are arranged round the funnel bases in a manner that saves both weight and space. The pigeon-hole shape given to the inlet of these ducts gives a distinctly curious appearance to the vessel. Obviously the design of the "Blücher" has been widely used as a basis in designing the "Von der Tann." The latter vessel has extremely clear decks, and Messrs. Blohm & Voss are to be congratulated on the success of the first vessel of the type of which they have three others—the "Moltke," "H" and "J"—in hand.

The two new German cruisers "Cohn" and "Augsburg" will make their trials next autumn. They are sister ships of 4,350 tons displacement, 426½ feet length, 46 feet greatest beam, and a draught of 16½ feet. The crew of each will number 363, the speed will be over 25 knots, and the coal capacity 900 tons. The trials of the two ships are being looked forward to with interest in engineering circles, as they are to be tested against the cruisers "Mainz" and "Kolberg" in order to ascertain the merits of the different turbine systems in use in Germany. The "Cohn's" turbines are Zoelly, the "Augsburg's" Parsons, the "Mainz's" Curtis, and the "Kolberg's" Schichau. The "Mainz" averaged 25 knots on her trials, but on one occasion reached 27.5 on the measured mile.

The reconstruction of the public works of Messina, Sicily, is the subject of a proposal made to the Italian government by an English syndicate. This city, it will be remembered, was destroyed by an earthquake in 1908. The syndicate, according to Engineering News, offers to build a breakwater, pier, military barracks, university, city hall and other public buildings and sewerage system within five years' time. It is reported that the banking firm of Stimons & Co., of London, is willing to advance the Italian government $115,000,000 at 3 per cent interest to carry on the work. According to a statement by United States Consul Arthur Garrels, of Catania, the whole matter is yet in a very tentative form, not having been made the subject of definite resolution before the Italian Chamber of Deputies. Mr. Garrels states that the English syndicate mentioned is headed by Mr. Sinclair Poley, proprietor of the London Daily Mail.

It is proposed to construct a tunnel or rather a series of tunnels under the sea in order to connect Denmark with Sweden. An electric railroad line will be run in the tunnel and partly overland. The matter has been brought forward by a commission of leading engineers, and in the present case the tunnel is not likely to meet with the opposition which prevented the idea of a tunnel from France to England from being carried out. Starting from Copenhagen, the tunnel will run under the sea, and in part upon the islands, ending in Sweden at the small town of Malmoe, which lies at the southeast. The proposed electric line will start from the central railroad depot of Copenhagen and run thence to the Island of Amack, which is now connected with Seeland by two bridges. From this point it enters in tunnel under the Sund and traverses this thence to the island of Amack, which is now connected of Saltholin. Crossing the island, it again descends in tunnel at its eastern extremity and passes under the sea to the Swedish coast, where it comes out at Schonene. The total length of the electric line will be 21 miles. The Swedish parliament is to consider the matter, and it is claimed that there are no great engineering difficulties in connection with the project.

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